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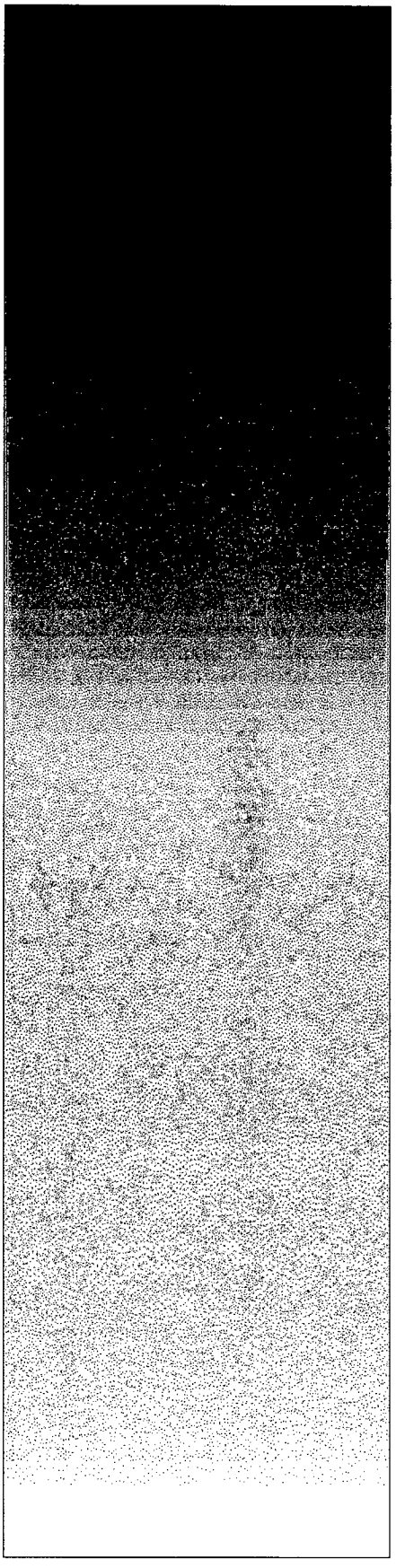

Radionuclide Air Emissions Annual Report

Calendar Year 1995

Rocky Flats Environmental Technology Site

U.S. Department of Energy

Radionuclide Air Emissions Annual Report for Calendar Year 1995

Prepared in accordance with 40 CFR 61, Subpart H and Regulation No. 8, Part A

Site Name: Rocky Flats Environmental Technology Site

Operations Office Information

Office: Rocky Flats Field Office

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Site Information

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Executive Summary

As required by Title 40 of the Code of Federal Regulations (CFR), Part 61, Subpart H and Colorado Air Quality Control Commission (CAQCC) Regulation No. 8, Part A, Subpart H, the radiation dose to the public from the Rocky Flats Environmental Technology Site (Site) is determined annually and reported to the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE). These regulations require that the dose to the public in any calendar year not exceed an effective dose equivalent (EDE) of 10 millirem per year (mrem/yr).

The dose was determined using the EPA-approved CAP88-PC dispersion model to simulate emissions from buildings and contaminated soils at the Site and was calculated for the nearest off-site resident. The EDE for the 1995 calendar year to the maximally exposed individual was calculated to be 0.0078 mrem/yr, which is less than 0.1% of the standard. Individuals living or working further from the Site received a lower dose.

The health risk associated with 1 mrem of EDE from naturally occurring sources of background radiation (such as uranium or thorium in rock or soil, cosmic rays, and radon emitted from soil or bedrock) is the same as that produced from anthropogenic sources of radiation, such as Site activities. The average annual EDE for residents of the Denver area from other sources of background radiation is greater than 350 mrem.

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ABBREVIATIONS AND ACRONYMS

Am	Americium
ANSI	American National Standards Institute
Be	Beryllium
Bq	Becquerel
CAQCC	Colorado Air Quality Control Commission
CDPHE	Colorado Department of Public Health and Environment
CFR	Code Of Federal Regulations
Ci	Curie
cm	Centimeter
DOE	U.S. Department Of Energy
DTA	Differential thermal analyzer
EDE	Effective dose equivalent
EIS	Effluent Information System
EPA	U.S. Environmental Protection Agency
ft	Foot
g	Gram
GIS	Geographic information system
HEPA	High efficiency particulate air (filter)
HQ	Headquarters
H-3	Tritium
IHSS	Individual Hazardous Substance Site
kg	Kilogram
km	Kilometer
km²	Square kilometer
LLMW	Low-level mixed wastes
LLW	Low-level waste
m	Meter
MEI	Maximally exposed individual
mi	Mile
mrem	Millirem
m/s	Meters per second
mSv/yr	MilliSievert per year
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NTS	Nevada Test Site
OU	Operable Unit

Pu	Plutonium
QC	Quality control
RCRA	Resource Conservation And Recovery Act
RFEDS	Rocky Flats Environmental Data Base System
RFFO	Rocky Flats Field Office
Site	Rocky Flats Environmental Technology Site
SNM	Special nuclear material
Sv/yr	Sievert per year
STP	Sewage Treatment Plant
TRU	Transuranic
U	Uranium
VOC	Volatile organic compound
yr	Year
µm	Micrometer
°C	Degrees Celsius
°F	Degrees Fahrenheit

1.0 INTRODUCTION

The Rocky Flats Environmental Technology Site (Site) is subject to National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities (Title 40 of Code of Federal Regulations [CFR], Part 61, Subpart H). Regulation 40 CFR 61, Subpart H applies to operations at any facility owned or operated by the U.S. Department of Energy (DOE) that emits radionuclides (other than radon-222 and radon-220) into the air. The standard requires that emissions of radionuclides to the ambient air from the Site not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 millirem per year (mrem/yr). Colorado has incorporated 40 CFR 61, Subpart H by reference as Colorado Air Quality Control Commission (CAQCC) Regulation No. 8, Part A, Subpart H.

Regulation 40 CFR 61, Subpart H, Section 61.94 requires the Site to calculate the EDE for the previous calendar year and to submit this information, along with other data, to the U.S. Environmental Protection Agency (EPA) in an annual report (Regulation No. 8, Part A, Subpart H requires submittal to the Colorado Department of Public Health and Environment [CDPHE]). This annual report fulfills the reporting requirements of 40 CFR 61.94 for the 1995 calendar year.

2.0 FACILITY INFORMATION

This section describes the Rocky Flats Environmental Technology Site (Site), lists the radioactive materials used at the Site, and describes the handling and processing that the radioactive materials undergo. New construction or modifications in calendar year 1995 for which construction approval or notification was waived per 40 CFR 61.96 and Regulation No. 8, Part A, Section 61.96 are also described in this section.

2.1 Site Description

The Rocky Flats Environmental Technology Site was part of a nationwide nuclear weapons research, development, and production complex. The Site is operated by Kaiser-Hill Company, L.L.C., with oversight by the Rocky Flats Field Office of the U.S. Department of Energy. Prior to 1989, the Site fabricated nuclear weapons components from plutonium (Pu), uranium (U), beryllium (Be), and stainless steel. Production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions. Plutonium weapons operations were curtailed at the Site in 1989 to address safety concerns. In February 1992, the Site's historical weapons production mission was discontinued. The Site is now undergoing decontamination and decommissioning, and is moving toward ultimate cleanup.

The Site occupies an area of 26.5 square kilometers (km^2) in northern Jefferson County, Colorado, approximately 25.7 kilometers (km) northwest of Denver. The Site is located at approximately 1,829 meters (m) above mean sea level on the eastern edge of a geological bench known locally as Rocky Flats. This bench, about 8.1 km wide in an east-west direction, flanks the eastern edge of the Rocky Mountains.

Approximately 2.1 million people live within an 83.7 km radius of the Site. Adjacent land use is a mixture of agriculture, open space, industry, and residential housing. Surrounding communities consist of the city of Golden to the south of the Site, the cities of Arvada, Broomfield, and Westminster to the east, and the city of Boulder to the north. A location map is shown in Figure 2-1.

The former production facilities are located near the center of the Site within a fenced security area of 1.6 km^2. The remaining Site area contains limited support facilities and serves as a buffer zone to former production facilities. A map of the Site is shown in Figure 2-2; a simplified map of the central portion of the Site showing the location of the former production facilities is shown in Figure 2-3.

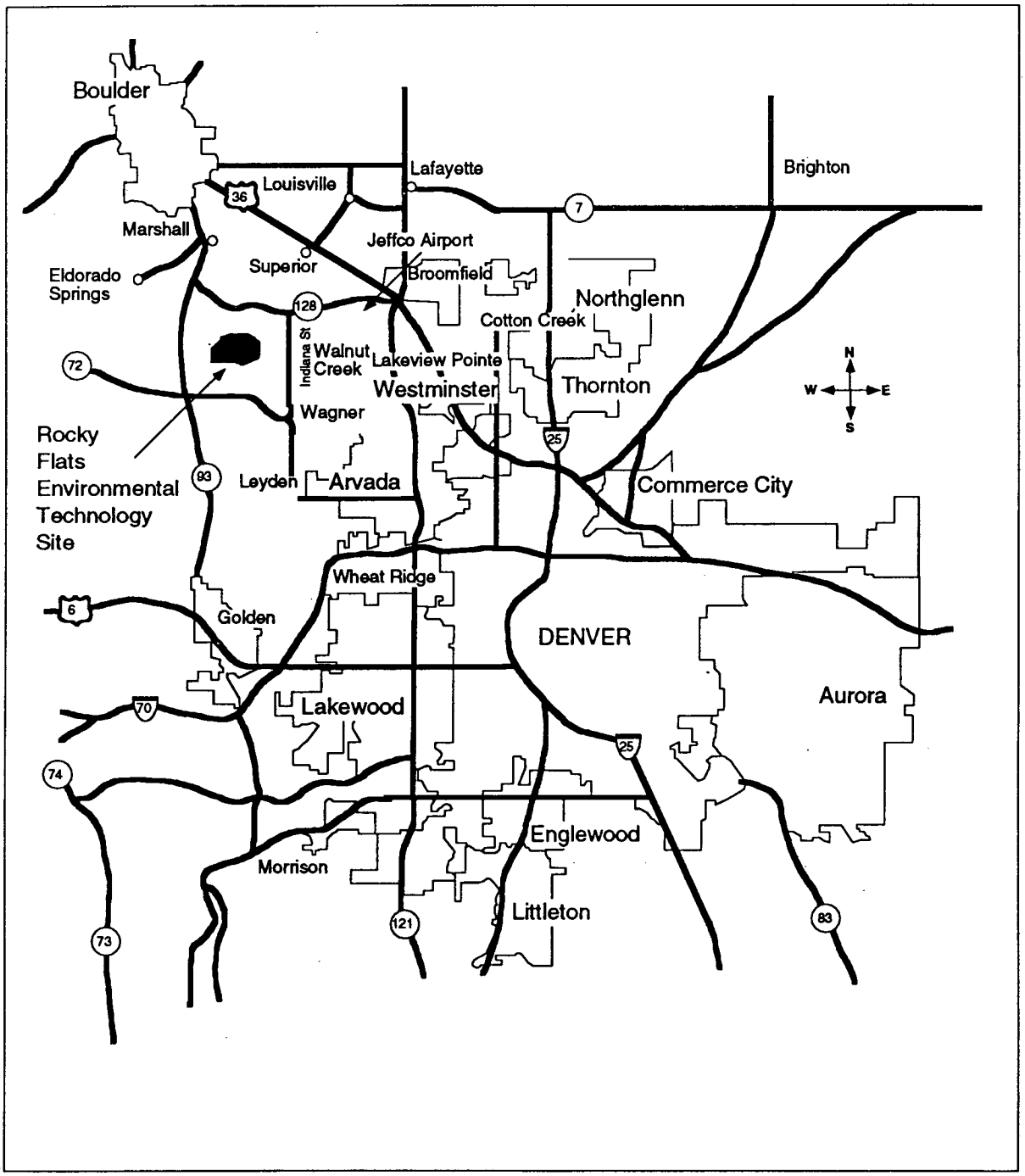


Figure 2-1. Area Map of the Rocky Flats Environmental Technology Site and Surrounding Communities

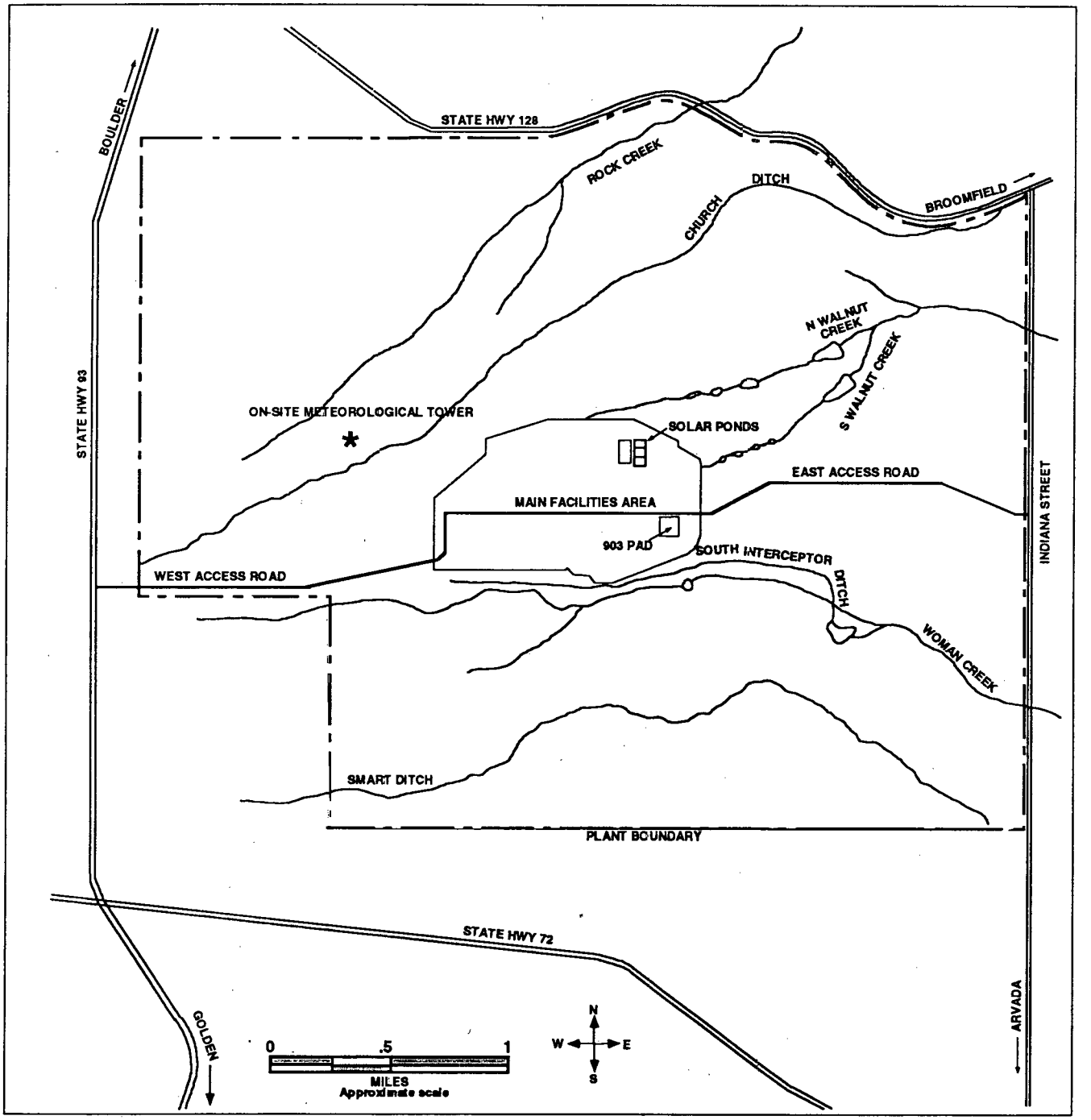


Figure 2-2. Rocky Flats Environmental Technology Site Location Map

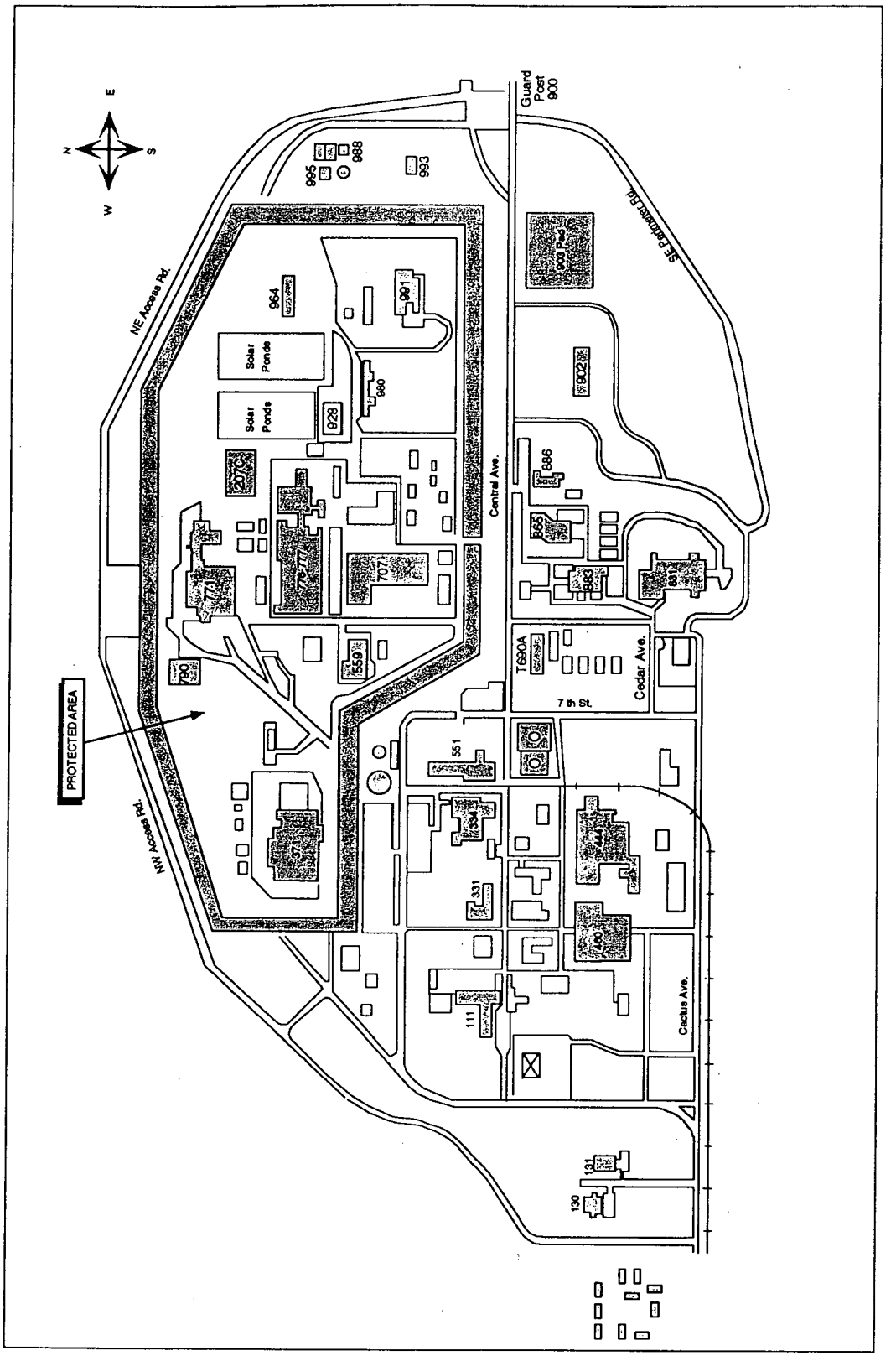


Figure 2-3. Central Portion of the Rocky Flats Environmental Technology Site

2.2 Radionuclide Air Emissions Source Description

The central portion of the Site, which houses the former production facilities, can be roughly divided into halves. The Protected Area, generally located in the north half of the central area (see Figure 2-3), historically housed Pu processing operations. The rest of the central area was involved with U, Be, and stainless steel operations.

Radioactive material processing can result in radionuclides becoming entrained in ventilation air (effluent) that is released through vents or stacks (point sources). Because no routine nuclear weapons-related processing has occurred at the Site since 1989, the majority of radionuclide point source emissions results from the resuspension of residual radioactive material in the ventilation systems of these buildings and from decontamination and deactivation activities taking place in the process buildings. Radioactive material handling at the Site is currently focused on material consolidation, cleanup, residue stabilization, waste processing, and analytical operations.

Air exhausted from process buildings in the industrial portion of the Site is cleaned prior to release by passing it through multiple stages of high efficiency particulate air (HEPA) filters. As a result, radionuclide point source emissions from the Site are very low. Most of the radionuclide air emissions from the Site result from non-point (diffuse) sources, primarily mechanical and natural disturbances of contaminated soil. Soil contamination is the result of past radioactive material spills and other releases.

2.2.1 Radioactive Materials Handling and Processing in Calendar Year 1995

Potential radionuclide emissions from the Site occur from a number of activities that disturb resident contamination or that process radionuclide-containing substances such that emissions to the atmosphere may result. Appendix A lists radioactive materials associated with the Site. The list of radionuclides includes plutonium-238, plutonium-239/240, americium-241, uranium-233/234, uranium-235, uranium-238, and tritium. The Site also has some quantities of beta- and gamma-emitting sealed sources and low activity analytical stock solutions, powders, and plated sources; emissions from these sources are negligible.

The activities or sources that contributed to calculated radionuclide emissions from the Site in the 1995 calendar year are described below.

Hold-up in Ducts: A large fraction of the potential point-source radionuclide emissions from the Site are from contaminant radionuclide dust and other deposits that are attached to surfaces in ventilation ducts exiting process areas. These materials were deposited on the duct walls and in rapidly decreasing amounts on the successive stages of the HEPA filter plena during many years

of weapons component production. This contamination has been verified through visual inspections of the ducts. It has been quantified in some areas through non-destructive assay measurements conducted external to the ducts along their lengths from the process gloveboxes to the filters. This material is assumed to be dispersible for the purposes of estimating emission potential for compliance with 40 CFR 61, Subpart H, and Regulation No. 8, Part A, Subpart H.

Resident Dispersible Contamination: In some process areas, contamination may be found on surfaces and floors in the gloveboxes and, in limited cases, in the rooms themselves. This contamination has been surveyed and estimated using surface swipes in the areas. Removable contamination has been assumed to be dispersible for the purposes of estimating emission potential for compliance with 40 CFR 61, Subpart H, and Regulation No. 8, Part A, Subpart H.

Waste Storage and Repackaging: Packaged low-level, low-level mixed, and transuranic (TRU) wastes are commonly stored in drums at various locations on the Site. In storage, many of these drums must be vented to prevent the buildup of pressure from hydrogen gas generated as a product of the reactions associated with radioactive decay of materials packaged in the drums. Venting is accommodated using small filter cartridges that function like HEPA filters for additional protection against emissions should the packaging fail. For the purposes of estimating emission potential for compliance with 40 CFR 61, Subpart H, and Regulation No. 8, Part A, Subpart H, the packaged materials inside these drums are sealed sources (according to Appendix D of 40 CFR 61 and Regulation No. 8, Part A).

Some of these waste drums must be repackaged to comply with waste storage and waste shipping requirements. Typically, radioactive wastes are repackaged inside enclosed structures or other designated permanent facilities. Emissions from the process are controlled by venting the air through HEPA filters. Materials in the waste drums are generally characterized by the waste forms known to be in the drums. If the waste form is not known or if the radioactive component of the waste is identified as contamination rather than a well-characterized solid material, the radioactive material is assumed to be a dispersible solid for the purposes of estimating emission potential during repackaging operations.

Consolidation of Special Nuclear Material (SNM): Consolidation activities related to SNM encompass metal brushing, size reduction of metal, thermal stabilization of oxide, and packaging and interim storage of SNM. SNM is characterized as plutonium and enriched uranium contained in weapons parts, metal and alloy, and oxide.

- Metal brushing: Mechanical removal of metal oxide from metal surfaces.

- Size reduction: Reduction of material size to accommodate storage containers by breaking, cutting, sawing, and pressing.
- Thermal stabilization of oxide: Treatment of unstable forms of metal oxides in furnaces operating in the range of 800-1200 °C to remove moisture and to fully oxidize the metal to stable form.
- Packaging and Storage: Placement of material in the approved, inert atmosphere, storage containers which in turn are placed in "storage vaults" or "vault-type rooms." Storage vaults are repositories of SNM materials that satisfy defined safety and risk criteria.

Waste Treatment Projects: Waste treatment and handling technologies for low-level, low-level mixed, and TRU materials include immobilization technologies, destruction technologies, separation technologies, and decontamination technologies. Most of the treatable waste materials were generated during plutonium production and refining operations conducted at the Site prior to 1989. Proposed technologies and treatment systems include repackaging, size reduction, residue stabilization, thermal desorption, cementation, polymer solidification, microwave vitrification, and chemical oxidation processes. Although options for treatment systems have been proposed, treatment configurations have not been instituted. However, laboratory scale research and development projects and pilot scale projects have been performed in support of proposed Site waste treatment plans.

Non-Point Sources: In addition to the processes and passive point sources that contribute to radionuclide emissions at the Site, another major contributor to emissions is the resuspension of contaminated soils. These emissions have been estimated using measured soil concentrations from throughout the buffer zone, including the OUs, and from a site-specific resuspension factor developed empirically over a several-year sampling period.

2.2.2 New Construction and Modifications in Calendar Year 1995

A total of 12 new or modified activities began operations during the 1995 calendar year. These activities were involved with radioactive materials stabilization, and deactivation, decontamination, and decommissioning activities at the Site. The estimated EDE from these activities was less than 1% of the standard. Because the Site is in compliance with this subpart, based on the annual report submitted for the 1994 calendar year, neither construction approval nor notification of startup was required for these activities. These new or modified activities are described below. Estimated emissions from these activities are discussed in Section 3.1.

Remediation of Trench T-2: OU No. 2

The OU No. 2 (OU2) Trench T-2 was used from approximately 1966 through 1970 to dispose of organic chemicals before the trench was backfilled and its use discontinued. The trench lies within an area where surficial soils are contaminated with americium-241 and plutonium-239. The

radionuclide contaminants were deposited by wind dispersion from the 903 Pad drum storage area.

Approximately 153 cubic meters (m^3) of material were removed from Trench T-2, resulting in emissions of radionuclide-contaminated soil to the ambient air. Dust suppression measures were used during excavation and material handling. The excavated soil was containerized and stored on site for future treatment. Emissions from this activity were modeled as an area source in calculating the 1995 calendar year maximum EDE. (Modeling methodology is discussed in Section 4.0 of this document.)

Passive Seep Collection and Treatment

The Passive Seep Collection and Treatment project is designed to intercept and treat water seeping from the Present Landfill into the East Landfill Pond in OU No. 7. The objective is to eliminate discharge to a surface water body of Resource Conservation and Recovery Act (RCRA) F039 listed waste contained in the seep water. The seep water contains dissolved metals, radionuclides, volatile organic compounds (VOCs), and semi-volatile organic compounds in concentrations that exceed water standards.

The seep interception system required the excavation of a trench near the base of the east face of the landfill. An interception system was installed and the trench was backfilled. Water spray was used to control dust emissions during earth moving activities. Radionuclide emissions were estimated based on dust emissions and the amount of contaminated seep water exposed to the atmosphere. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Polymer Encapsulation

Polymer encapsulation is being evaluated as a treatment process for encapsulation and solidification of low-level mixed wastes (LLMW) generated at the Site. The objective of the evaluation is to demonstrate the ability of the process to meet Nevada Test Site (NTS) waste acceptance criteria. The pilot-scale demonstration is being conducted in Building 779 and is evaluating the process using several types of waste, including nitrate salt, ash, glass, sludge, chemicals, and soils. Process effluent is filtered through two stages of HEPA filters prior to release to the atmosphere. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Cement Encapsulation

Cement encapsulation is being evaluated as a treatment process for encapsulation and solidification of LLMW generated at the Site. The objective of the evaluation is to demonstrate the ability of the process to meet NTS waste acceptance criteria. The pilot-scale demonstration is being conducted in Building 779 and is evaluating the process using several types of waste, including nitrate salt, ash, glass, sludge, chemicals, and soils. Process effluent is filtered through two stages of HEPA filters prior to release to the atmosphere. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Deactivation, Decontamination, and Decommissioning of Rooms 415/416 in Building 777

Rooms 415 and 416 were used as a plutonium metallography laboratory where metal specimens were prepared and examined. Due to the change in Site mission from production to cleanup and environmental restoration, there is no further use for this equipment. Deactivation, decontamination, and decommissioning of Rooms 415 and 416 in Building 777 took place in 1995 and involved isolating and removing all unnecessary support equipment and systems, removing gloveboxes, and removing unutilized Zone 1 (glovebox) ventilation systems. These activities disturbed approximately 1,880 grams (g) of plutonium in solid particulate form from hold-up in ducts and resident dispersible contamination; air effluent from these activities was vented through HEPA filters prior to release to the atmosphere. Emissions from these activities were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Deactivation, Decontamination, and Decommissioning of Rooms 152/154 in Building 779

Rooms 152 and 154 in Building 779 were used to support the hydrating process. Parts with recoverable plutonium were processed to remove plutonium in the form of plutonium hydride. The hydride was then dehydrated and converted to plutonium metal or oxidized to plutonium oxide.

Due to the change in Site mission from production to cleanup and environmental restoration, there is no further use for the equipment in Rooms 152 and 154. Deactivation, decontamination, and decommissioning of Rooms 152 and 154 in Building 779 took place in 1995 and involved isolating and removing all unnecessary support equipment and systems, removing gloveboxes, and removing unutilized Zone 1 (glovebox) ventilation systems. These activities disturbed plutonium in solid particulate form from hold-up in ducts and resident dispersible contamination; air effluent from these activities was vented through HEPA filters prior to release to the atmosphere. Emissions from these activities were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Sewage Treatment Plant Phase II Upgrade

Phase II of the Sewage Treatment Plant (STP) upgrades involved excavation of a portion of the STP site to allow expansion of Buildings 988 and 995. Building 988 is being expanded to enclose the outside pressure sand filters and to provide dry chemical storage. Building 995 is being expanded to provide laboratory facilities, office space, locker rooms, and records storage.

A trench was excavated in 1995 to allow installation of a drain line to remove surface water from the area as part of this project. The trench was excavated through an area with low levels of radionuclide soil contamination. Water spray was used to control dust emissions during excavation and backfill. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Waste Segregation: Cargo Container C-549-1

A waste segregation area was established in Cargo Container C-549-1. The function of this area is to provide a radiologically controlled environment for investigation into potentially contaminated or known contaminated items, and to enable contaminated portions of items or equipment to be surveyed, evaluated, and segregated from uncontaminated pieces, thereby minimizing waste. Contaminated items are handled in a hood or immediately adjacent to a "snorkel" arm to capture contaminants. Air effluent discharged from the facility is controlled by HEPA filters. The maximum annual inventory of radioactivity of all items inspected was no greater than 10 microcuries of any combination of plutonium-239/240, americium-241, uranium-235, or uranium-238. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Thermal Stabilization

Thermal stabilization of pyrophoric plutonium, which was discontinued in 1989, was resumed in Building 707 during 1995. Potentially pyrophoric plutonium is collected from housekeeping and inspection activities at the Site. The pyrophoric plutonium is heated under controlled conditions in a glovebox furnace to promote full oxidation and to convert the material into stable plutonium oxide. This activity is expected to continue as long as plutonium is stored at the Site. The maximum quantity of plutonium that will be stabilized in any year will be 200 kilograms(kg). Air effluent discharged from this activity is controlled by HEPA filters. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Differential Thermal Analyzer

A differential thermal analyzer (DTA) was installed in Building 559. The new DTA replaced an existing DTA that was incapable of analyzing the larger samples associated with residue characterization. The capacity of the analysis operation has increased as a result. The new equipment can analyze up to 500 grams of residue samples per year. The residue samples may contain as much as 40% plutonium. Air effluent is controlled by HEPA filters. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Sampling, Venting, and Aspiration of Radioactive Waste Containers

Drums containing radioactive waste must be vented through a carbon filter to prevent hydrogen gas accumulation due to continuing radiolysis. Drum venting activities began in 1995; up to 4,000 drums per year may be processed at one or more of the following locations: the size reduction vault airlock in Room 146, Building 776; the advanced size reduction facility in Room 134, Building 776, or Rooms 3204 and 3602, Building 371. Processing included sampling and aspiration of the drums' headspace, as well as the installation of venting devices. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

Residue Sampling and Characterization Activities

Beginning in 1995, a program was undertaken to sample and characterize plutonium-containing residues so that decisions can be made regarding the final disposition of the materials. Containers of plutonium-containing residue were staged in Module A of Building 707 prior to sampling and characterization. Containers were opened one at a time in a glovebox and the contents, their packaging, and the containers themselves were inspected, sampled, analyzed, and, if needed, repackaged. Four containers were sampled and characterized in 1995. Both Module A and the glovebox used are vented through HEPA filters. Emissions from this activity were included as part of a combined point source in calculating the 1995 calendar year maximum EDE.

3.0 AIR EMISSIONS DATA

This section lists the stacks, vents, or other points where radioactive materials are released to the atmosphere and describes the effluent controls employed by the Site.

3.1 Point Sources

Point source emissions for calendar year 1995 and the control technology used on each point source are described in this section.

3.1.1 Point Source Emissions

Radionuclide point source emissions occur at various locations throughout the central portion of the Site and nearby areas. Point sources that have an estimated uncontrolled (without HEPA filtration) potential to result in an EDE to the public greater than 0.1 mrem/yr (0.001 Sieverts per year [Sv/yr]) require continuous effluent monitoring for radionuclides. There were 22 such significant point sources at the Site in 1995. Emissions of Pu, U, and Am from the significant air effluent emission points are shown in Table 3-1. Five of these points are also sampled for tritium, as indicated in Table 3-1. Tritium samples are analyzed as they are collected, twice a week.

An additional 41 ducts or vents (constituting 31 other emission points) with potential dose terms that are less than 0.1 mrem/yr (0.001Sv/yr) require only periodic confirmation of low emissions. In calendar year 1995, continuous emission sampling continued at these "insignificant" point source locations. Air effluent samples from these insignificant point sources were collected and each filter screened for long-lived alpha and beta radiation. Samples were then composited for each location and radiochemically analyzed for Pu, U, and/or Am as appropriate.

Analysis frequency for Pu, U, and Am at insignificant locations was reduced in late 1995 from a monthly analysis schedule to an annual schedule. To complete the 1995 calendar year, a 3-month composite (October, November, and December) was analyzed and results added to those from the previous monthly analyses at each insignificant location. Emissions of Pu, U, and Am for calendar year 1995 for the insignificant, monitored point source locations are also shown in Table 3-1. One location also monitors tritium, as shown in Table 3-1. As noted above, tritium samples are collected and analyzed twice a week.

In the future, annual composite samples will be analyzed for Pu, U, and Am for each insignificant duct or vent sampled; this will allow quantification of total annual air emissions for the purpose of demonstrating compliance with the 10 mrem/yr standard.

Table 3-1

Monitored Point Source Emission Rates

Building/ Location	Isotope Emissions (Ci/yr) [a,b]					
	Pu-238	Pu-239/ 240	Am-241	U-233/ 234	U-238	H-3
Significant Sources						
371-N01	7.20 E-11	5.13 E-09	9.09 E-10	1.80 E-08	2.02 E-08	
371-N02	6.23 E-11	1.52 E-09	7.15 E-10	1.55 E-08	1.69 E-08	--
371-SSS	- 4.20 E-11	2.73 E-09	6.88 E-10	1.79 E-08	2.17 E-08	--
374-MAI	- 2.68 E-11	4.00 E-09	1.94 E-09	- 6.96 E-09	- 1.01 E-09	--
559-561	- 7.58 E-11	2.47 E-09	7.03 E-10	2.95 E-08	3.51 E-08	--
707-101	- 8.44 E-13	3.96 E-11	- 2.04 E-11	6.14 E-11	1.16 E-10	--
707-102	- 1.39 E-11	7.83 E-11	- 2.01 E-11	9.56 E-11	2.53 E-10	6.93 E-02
707-105	- 1.31 E-11	6.11 E-10	3.69 E-10	5.83 E-09	5.94 E-09	--
707-106	8.79 E-12	1.94 E-10	1.48 E-11	1.22 E-10	4.86 E-10	--
707-107	- 1.33 E-10	7.50 E-10	2.23 E-10	1.07 E-08	1.20 E-08	--
707-108	- 3.97 E-10	1.43 E-09	1.79 E-09	4.94 E-09	5.57 E-09	--
771-MAI	2.56 E-09	1.52 E-07	3.09 E-08	1.04 E-07	1.12 E-07	--
774-202	1.69 E-11	2.59 E-10	1.05 E-10	- 7.84 E-10	2.78 E-11	--
776-201	- 7.16 E-12	6.61 E-11	4.63 E-13	6.75 E-11	1.06 E-10	--
776-202	1.19 E-11	1.06 E-09	9.98 E-11	5.69 E-10	1.40 E-09	--
776-204	- 1.19 E-10	1.98 E-09	5.81 E-10	1.17 E-09	1.32 E-08	--
776-205	- 3.46 E-11	5.53 E-10	5.30 E-11	4.87 E-10	1.01 E-09	3.22 E-01
776-206	4.41 E-11	1.17 E-09	6.94 E-11	1.55 E-09	2.07 E-09	1.06 E 00
776-207	- 1.07 E-10	5.27 E-10	5.02 E-11	8.74 E-10	1.62 E-09	--
776-250	- 2.11 E-10	1.38 E-09	3.93 E-09	1.73 E-08	2.16 E-08	1.90 E 00
779-729	3.25 E-12	1.14 E-09	6.60 E-11	1.78 E-09	4.70 E-10	--
779-782	- 1.90 E-10	3.09 E-09	2.98 E-09	3.92 E-08	4.31 E-08	1.61 E 00
Insignificant Sources						
374-SPD	5.55 E-11	2.16 E-09	1.84 E-09	6.77 E-09	7.60 E-09	--
444-DO5	--	--	--	- 1.41 E-08	- 1.31 E-08	--
444-MAI	--	--	--	9.64 E-08	1.01 E-08	--
447-MAI	--	--	--	7.26 E-08	7.98 E-08	--
707-R21A/B	6.53 E-13	2.33 E-09	4.94 E-09	1.38 E-09	2.00 E-08	--
707-R22A/B	- 3.47 E-11	2.23 E-09	6.69 E-09	2.03 E-08	2.33 E-08	--
707-R23A/B	6.06 E-10	2.39 E-09	3.88 E-09	1.55 E-08	1.42 E-08	--
707-R24A/B	6.46 E-11	2.32 E-09	4.17 E-09	1.62 E-08	2.04 E-08	--
707-R25A/B	1.06 E-09	1.39 E-09	2.84 E-09	7.49 E-09	8.44 E-09	--
707-R26A/B	1.85 E-10	1.61 E-09	4.38 E-09	1.78 E-08	2.71 E-08	--
707-R27A/B	7.84 E-11	3.32 E-09	1.49 E-09	- 3.09 E-08	2.80 E-08	--

Table 3-1

Monitored Point Source Emission Rates (Continued)

Building/ Location	Isotope Emissions (Ci/yr) [a,b]					
	Pu-238	Pu-239/ 240	Am-241	U-233/ 234	U-238	H-3
Insignificant Sources						
707-R45A/B	- 8.17 E-11	2.41 E-09	3.59 E-09	1.73 E-08	2.13 E-08	--
707-R46A/B	- 6.35 E-12	2.53 E-09	2.50 E-09	1.76 E-08	2.09 E-08	--
771-CMA	7.95 E-12	1.46 E-09	1.04 E-09	3.19 E-09	4.13 E-09	--
771-CRM8/10	4.43 E-10	4.31 E-08	2.01 E-09	6.11 E-09	7.52 E-09	--
776-251	- 1.72 E-10	1.31 E-09	1.22 E-09	2.95 E-08	3.57 E-08	1.31 E 00
776-252	- 8.47 E-11	5.23 E-10	5.82 E-10	3.71 E-09	3.70 E-09	--
778-LDY	2.09 E-09	6.54 E-08	7.57 E-09	2.20 E-08	1.02 E-07	--
865-EEE	--	--	--	3.46 E-08	3.69 E-08	--
865-WWW	--	--	--	6.79 E-08	7.18 E-08	--
881-MA1	- 3.15 E-10	4.34 E-09	4.15 E-09	7.26 E-08	8.57 E-08	--
881-MA2	- 5.95 E-10	7.36 E-09	1.34 E-08	1.50 E-07	1.47 E-07	--
881-MA3	- 4.38 E-10	3.77 E-09	6.35 E-09	6.80 E-08	7.73 E-08	--
881-MA4	7.03 E-11	1.80 E-09	5.69 E-09	6.64 E-08	6.36 E-08	--
883-AAA	--	--	--	6.94 E-08	6.91 E-08	--
883-BBB	--	--	--	8.22 E-08	9.62 E-08	--
883-CCC	--	--	--	2.40 E-08	3.72 E-08	--
886-875	- 2.44 E-11	3.35 E-10	1.07 E-09	5.41 E-09	7.36 E-09	--
889-MAI	1.63 E-11	4.79 E-10	3.05 E-10	- 6.41 E-09	- 5.54 E-09	--
991-985	6.36 E-11	4.58 E-09	5.40 E-09	1.17 E-08	8.28 E-09	--
991-MAI	- 3.78 E-11	3.56 E-10	8.47 E-10	8.48 E-09	8.86 E-09	--

[a] Values are corrected for filter blanks. Negative values result when observed measurements are less than filter blanks. Sources showing negative values were modeled with an emission rate of 0 Ci/yr in calculating EDE.

[b] All monitored point sources are controlled by HEPA filters with a tested control efficency of 99.97%.

Notes:

Ci/yr	=	Curies per year; 1 Ci = 3.7 x 10^{10} Becquerel (Bq)
Pu	=	Plutonium
Am	=	Americium
H-3	=	Tritium
U	=	Uranium
E#	=	x $10^{\#}$
--	=	Not Applicable

Table 3-2 shows modeled emissions from insignificant, unmonitored point sources and from unmonitored project-related sources. The latter category includes two projects (the Passive Seep Collection and Treatment system and the Sewage Treatment Plant Phase II upgrades) that disturbed small areas of contaminated soils. Due to the small areas of disturbance and low emission rates, these sources have been included as part of a combined point source in calculating EDE. These projects were described in Section 2.2.2 of this report; the modeling protocol and data used to calculate EDE are described in Section 4.0.

Emissions of Pu, U, and Am were estimated for Cargo Container C-549-1 using emission factors in Appendix D to 40 CFR 61 and Regulation No. 8, Part A. The waste segregation project in Cargo Container C-549-1 was described in Section 2.2.2 of this report.

The Centralized Waste Storage Facility was constructed in 1994 and was described in the Radionuclide Air Emissions Annual Report for the Site for calendar year 1994 (DOE, 1995). Emissions from this facility were estimated in the 1994 report using conservative assumptions. Additional evaluation demonstrated that the packaged materials inside these drums are sealed sources and do not contribute to Site emissions.

Buildings 123, 881, and 790 have low-level tritium emissions for which monitoring is not performed. Tritium emissions from these locations were estimated using emission factors in Appendix D to 40 CFR 61 and Regulation No. 8, Part A. These emissions are also listed in Table 3-2.

Appendix B shows point source emissions data contained in DOE's Effluent Information System (EIS). DOE did not publish an EIS report for 1995.

3.1.2 Control Technology

Air effluent from Pu processing areas is cleaned by a minimum of four stages of HEPA filters. Air effluent from areas that process Pu-contaminated waste is typically cleaned by two stages of HEPA filters. Air effluent from U processing areas is generally cleaned by a minimum of two stages of HEPA filters. Filters are bench tested prior to installation to ensure that they meet a minimum filter efficiency of 99.97%. The filters are tested with a dioctyl phthalate aerosol of a nominal 0.3 micrometer particle size. Filter assemblies are tested again for leaks following installation into a filter stage/plenum.

All of the monitored point source locations listed in Table 3-1 use HEPA filtration, which controls particulate emissions. In addition, the waste segregation area in Cargo Container C-549-1 is equipped with HEPA filtration.

Table 3-2

Unmonitored Point Source Emission Rates

Building/Location	Isotope Emissions (Ci/yr) [a,b]						
	Pu-238	Pu-239/ 240	Am-241	U-233/ 234	U-235	U-238	H-3
Passive Seep Collection and Treatment[a]	6.32 E-12	6.46 E-12	2.40 E-09	5.74 E-09	2.15 E-10	7.18 E-09	2.80 E-03
Sewage Treatment Plant Phase II[a]	--	8.00 E-08	3.60 E-08	4.10 E-08	2.60 E-09	4.60 E-08	--
Waste Segregation C-549-1[b]	--	1.00 E-08	1.00 E-08	--	1.00 E-08	1.00 E-08	--
Centralized Waste Storage Facility[c]	--	0.00 E 00	--	--	--	--	--
123 (Group of 4)[d]	--	--	--	--	--	--	6.06 E-10
881-MAI (Group of 4)[d]	--	--	--	--	--	--	6.74 E-09
790[d]	--	--	--	--	--	--	5.00 E-07

[a] Water spray/dust suppression used, with a control efficiency of 50%

[b] HEPA filtration used with a control efficiency of 99.97%

[c] Packaged waste materials in drums are sealed sources which do not contribute to Site emissions.

[d] Uncontrolled for tritium.

Notes:

Pu	=	Plutonium
Am	=	Americium
U	=	Uranium
H-3	=	Tritium
--	=	Not Applicable
E#	=	x $10^{\#}$
Ci/yr	=	Curies per year; 1 Ci = 3.7 x 10^{10} Becquerel (Bq)

Particulate emissions from earth moving activities at the Site, such as those involved in the Passive Seep Collection and Treatment project and the Sewage Treatment Plant Phase II upgrades, were controlled by water spray or other dust suppression measures with a control efficiency of at least 50%.

The tritium emissions shown in Tables 3-1 and 3-2 were uncontrolled (HEPA filters do not control tritium, which is released as a gas).

Packaged waste that is stored in drums in the Centralized Waste Storage Facility is sealed in plastic sheets inside the drums and does not contribute to Site emissions.

3.2 Non-Point Sources

A major contributor to radionuclide emissions from the Site is the resuspension of contaminated soils. As noted previously, these emissions were estimated using measured soil concentrations from throughout the buffer zone, combined with a site-specific resuspension factor developed over a several-year sampling period.

Surface soil radionuclide concentration data from the buffer zone was combined to develop a set of estimated concentration isopleths spanning the entire site. Potential sources of resuspended materials are encompassed by these isopleths. The surface soil concentrations of radionuclide contaminants in each isopleth were combined with a soil resuspension rate to estimate emission potential. Appendix C discusses the development of the Site-specific soil resuspension rate used in these calculations.

In addition to emissions from resuspension of contaminated soil by wind erosion, one project-related source was modeled as a non-point source. The soil handling activities associated with the Trench T-2 remediation in OU2 were modeled as a separate area source. This activity was described in Section 2.2.2 of this report. Water spray or other dust suppression measures were used during earth moving activities to provide at least 50% control of dust emissions.

Table 3-3 summarizes emissions from non-point sources. These emissions include the U isotopes typical of depleted and enriched U that have been used at the Site. Emissions for selected Pu isotopes (plutonium-238, -241, and -242) were not included in the dose calculation because each has the potential to contribute much less than 10% of the total EDE (See 40 CFR 61.93 [b][4]); soil samples are not analyzed for these isotopes. Plutonium-239/240 constitutes more than 97% of the alpha activity in plutonium used at the Site.

Non-point sources are discussed further in Section 4.2 of this report.

Table 3-3

Non-Point Source Emission Rate Summary

Isopleth No.[a]	Isotope Emissions (Ci/yr)					
	Pu-239/240	Am-241	U-233/234	U-235	U-238	H-3
Isopleth 1	8.26 E-07	3.17 E-07	6.49 E-09	2.32 E-08	1.00 E-10	--
Isopleth 2	3.55 E-08	5.55 E-09	4.90 E-08	2.00 E-09	2.21 E-09	--
Isopleth 3	8.61 E-07	4.24 E-09	4.84 E-09	2.37 E-08	1.57 E-08	--
Isopleth 4	4.10 E-08	1.57 E-08	3.09 E-08	9.79 E-10	1.37 E-08	--
Isopleth 5	2.33 E-06	8.21 E-10	5.76 E-08	2.01 E-08	5.02 E-09	--
Isopleth 6	9.53 E-08	8.06 E-09	6.58 E-09	--	5.92 E-10	--
Isopleth 7	1.62 E-07	1.20 E-06	3.37 E-08	--	2.88 E-09	--
Isopleth 8	3.31 E-06	6.00 E-08	7.25 E-08	--	--	--
Isopleth 9	3.43 E-08	8.44 E-09	6.27 E-09	--	--	--
Isopleth 10	3.25 E-06	1.02 E-08	9.58 E-08	--	--	--
Isopleth 11	3.89 E-07	4.18 E-07	8.33 E-08	--	--	--
Isopleth 12	4.18 E-08	5.11 E-08	3.80 E-09	--	--	--
Isopleth 13	5.13 E-07	5.59 E-07	8.80 E-08	--	--	--
Isopleth 14	1.99 E-06	1.00 E-07	--	--	--	--
Isopleth 15	1.94 E-07	6.03 E-07	--	--	--	--
Isopleth 16	2.76 E-06	6.86 E-07	--	--	--	--
Isopleth 17	5.12 E-06	8.81 E-07	--	--	--	--
Isopleth 18	5.17 E-06	5.44 E-07	--	--	--	--
Isopleth 19	5.17 E-06	--	--	--	--	--
Isopleth 20	3.26 E-06	--	--	--	--	--
Trench T-2/ OU/2	8.72 E-05	4.00 E-05	6.00 E-05	2.50 E-06	6.60 E-05	9.80 E-08

[a] Isopleths are specific to each isotope. Centroid locations for the isopleths modeled are shown in Figures 4-3 through 4-7.

Notes:

Ci/yr	=	Curies per year; 1 Ci = 3.7 x 10^{10} Becquerel (Bq)
Pu	=	Plutonium
Am	=	Americium
U	=	Uranium
H-3	=	Tritium
--	=	Not Applicable
E#	=	x $10^{\#}$

4.0 DOSE ASSESSMENT

This section describes the dose assessment performed for the Site for the 1995 calendar year.

4.1 Description of Dose Model

The Site used the dose model CAP88-PC (Version 1.0) for calculating EDE to the public.

4.2 Summary of Model Input Data

This section describes the input data used to calculate EDE to the public for the 1995 calendar year.

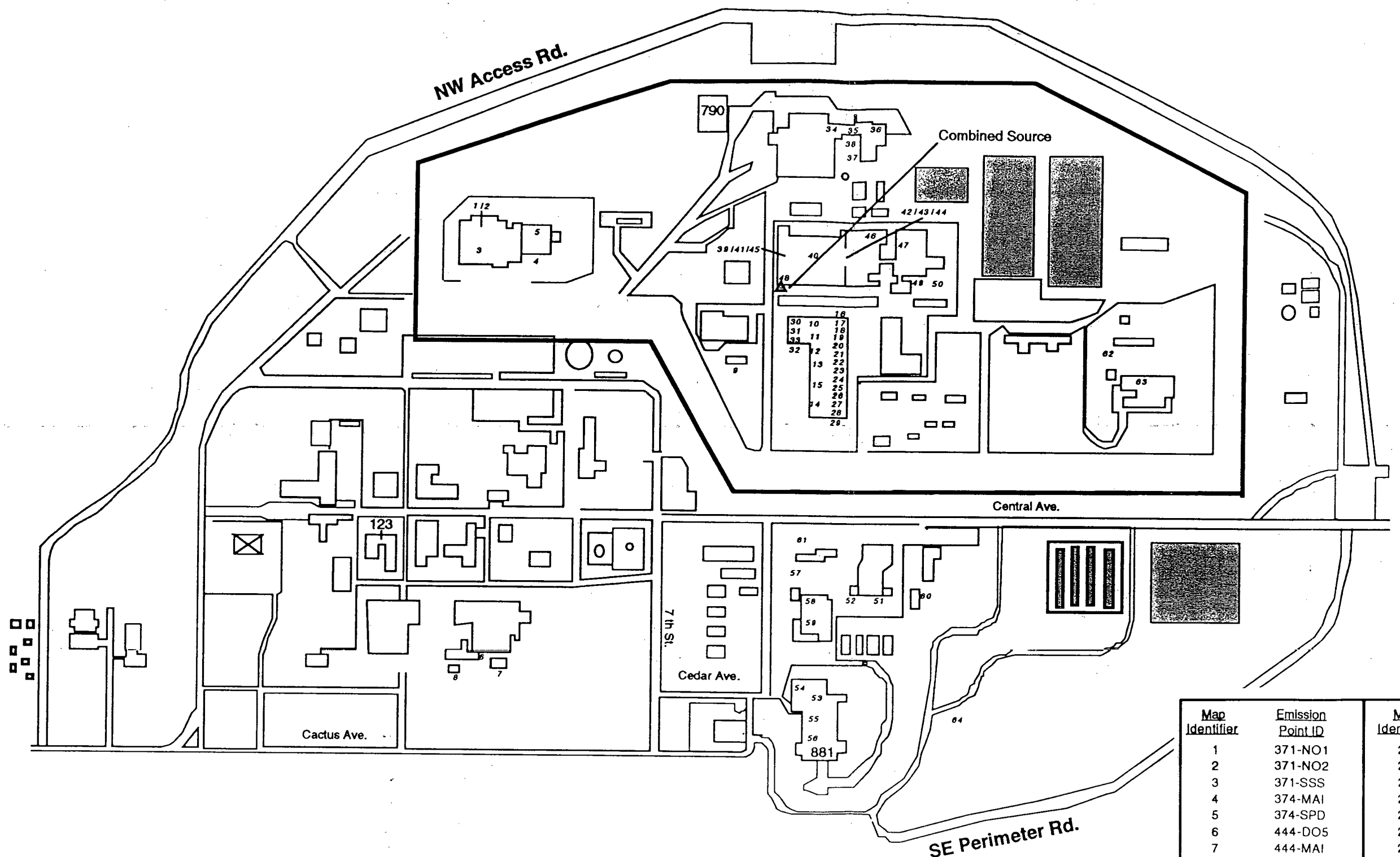
4.2.1 Point Source Input Data

Because individual point sources of radionuclide emissions at the Site contribute a small amount to the total dose, all point source emissions were conservatively combined and modeled from a single location within the central area of the Site. The combined emissions were modeled at an average release height using a conservative stack diameter (based on actual stack data) and an exit velocity characteristic of obstructed flow (such as would occur at a release point with a non-vertical stack or rain cap). Several sets of stack parameters were screened to determine which set would result in the highest point source EDE to the public. The emission rate modeled includes emissions from two of the small area (diffuse) source activities described in Section 3.1.1 (Passive Seep Collection and Treatment and Sewage Treatment Plant Phase II), as well.

Figure 4-1 shows the location of individual emission sources that were combined for modeling purposes, as well as the location from which the combined emissions were modeled. Figure 4-2 shows the location of two projects whose emissions were also combined for the point source modeling: the Passive Seep Collection and Treatment system and the Sewage Treatment Plant Phase II upgrades. Table 4-1 shows the stack parameters for the combined emissions source. (Source input data for the Trench T-2 remediation activities, which were modeled as an individual area source, are also shown in Table 4-1.) Detailed information regarding individual point source stack data is given in Appendix D.

4.2.2 Non-Point Source Input Data

As described in Section 3.2, emissions from soil resuspension were estimated based on concentration isopleths for the Site and vicinity that have been developed based on a soil sampling database (Rocky Flats Environmental Data Base System [RFEDS]), combined with geographic information system (GIS) software. No new soil concentration data were available for



Map Identifier	Emission Point ID	Map Identifier	Emission Point ID	Map Identifier	Emission Point ID
1	371-NO1	23	707-R24B	45	776-250
2	371-NO2	24	707-R25A	46	776-251
3	371-SSS	25	707-R25B	47	776-252
4	374-MAI	26	707-R26A	48	778-LDY
5	374-SPD	27	707-R26B	49	779-729
6	444-DO5	28	707-R27A	50	779-782
7	444-MAI	29	707-R27B	51	865-EEE
8	447-MAI	30	707-R45A	52	865-WWW
9	559-561	31	707-R45B	53	881-MA1
10	707-101	32	707-R46A	54	881-MA2
11	707-102	33	707-R46B	55	881-MA3
12	707-105	34	771-CMA	56	881-MA4
13	707-106	35	771-CRM8	57	883-AAA
14	707-107	36	771-CRM10	58	883-BBB
15	707-108	37	771-MAI	59	883-CCC
16	707-R21A	38	774-202	60	886-875
17	707-R21B	39	776-201	61	889-MA1
18	707-R22A	40	776-202	62	991-985
19	707-R22B	41	776-204	63	991-MA1
20	707-R23A	42	776-205	64	C-549-1
21	707-R23B	43	776-206		
22	707-R24A	44	776-207		

Figure 4-1. Point Source Locations

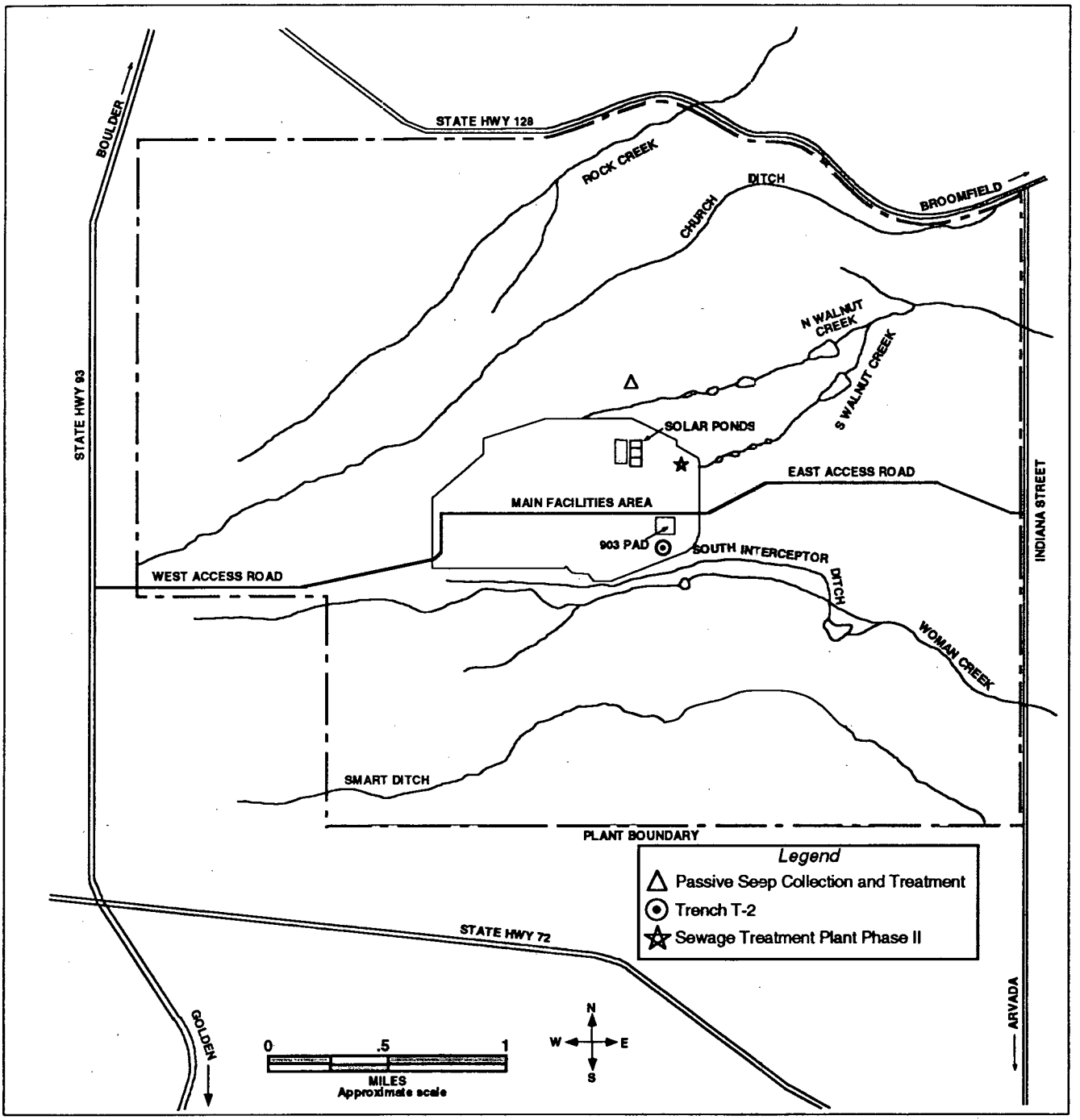


Figure 4-2. Project Emission Locations

Table 4-1

Source Data for Model Input

Parameter	Combined Point Source Values	Trench T-2 Values
Height (m)	9.1	0
Diameter (m)	0.4	167.2[a]
Exit Velocity (m/s)	0.1	--
Distance to MEI (m)	4,064	3,215
Direction to MEI	SE	SE

[a] Area of Trench T-2 in square meters.

Notes:

m	=	Meters
m/s	=	Meters per second
MEI	=	Maximally exposed individual

this year; therefore, the emissions modeled for non-point sources correspond to those modeled in the 1994 calendar year report.

The GIS was used to compute the area of each isopleth, the centroid of each isopleth, and the distances from each centroid to each receptor (receptors are described in Section 4.2.3 of this report). The area of each isopleth and the distance and direction to the maximally exposed individual (MEI) receptor are shown in Tables 4-2 through 4-6 for each of the isotopes modeled.

CAP88-PC simulates each area source as a point source in the center of the area if the receptor is outside the area source (e.g., at the centroid locations for soil isopleths). The location of the Trench T-2 remediation source is shown in Figure 4-2 (source input data for this source were listed in Table 4-1). The centroid locations that were modeled are shown in Figures 4-3 through 4-7. Soil emissions were simulated as groundlevel releases (height = 0.0m) with no momentum plume rise (exit velocity = 0.0 meters per second [m/s]).

4.2.3 Receptors

Modeling was performed for six potential MEI receptor locations, shown on Figure 4-8. These locations represent the residences, businesses, schools, and office buildings nearest the Site. Modeling determined that the MEI was located at a distance of 3,900 m to the southeast of the central, industrialized portion of the Site.

4.2.4 Meteorological Data

Meteorological data for calendar year 1995 were collected from a tower located in the western portion of the buffer zone (the tower location is shown in Figure 2-2). A joint frequency distribution of wind speed, wind direction, and stability was processed for input to CAP88-PC using a commercially available software program (BEEMET). A "wind rose" graphical representation of the meteorological data is shown in Figure 4-9. Appendix E gives a detailed listing of the joint frequency meteorological data for calendar year 1995.

Annual precipitation and temperature data for calendar year 1995 are summarized in Table 4-7. These data were also collected on Site. An average mixing height for the Denver, Colorado, area of 1,405 m was used in the model (EPA, 1972).

4.2.5 Other Input Data

The CAP88-PC model also requires other input data. Model default values were used for the median aerodynamic diameter (1.0 micrometer [µm]) and solubility class. Urban agricultural data were used in

Table 4-2

Americium-241 Non-Point Source Model Input Data[a]

Isopleth No.	Area (m^2)	Distance to MEI (m)[b]	Direction to MEI[b]
Isopleth 1	8,435,258	2,621	ESE
Isopleth 2	95,570	3,459	SE
Isopleth 3	2,978,028	2,372	SE
Isopleth 4	116,806	3,751	SE
Isopleth 5	4,354	3,560	SE
Isopleth 6	42,732	1,064	SE
Isopleth 7	1,901,048	2,479	SE
Isopleth 8	87,078	3,734	SE
Isopleth 9	4,477	3,866	SE
Isopleth 10	5,414	3,741	SE
Isopleth 11	305,065	3,054	SE
Isopleth 12	27,106	2,524	SE
Isopleth 13	217,109	3,057	SE
Isopleth 14	12,556	2,971	SE
Isopleth 15	104,835	3,122	SE
Isopleth 16	64,360	3,146	SE
Isopleth 17	34,105	3,163	SE
Isopleth 18	7,504	3,178	SE

[a] All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

[b] From isopleth centroids.

Notes:

m	=	Meters
m2	=	Square meters
MEI	=	Maximally exposed individual

Table 4-3

Plutonium-239/240 Non-Point Source Model Input Data[a]

Isopleth No.	Area (m^2)	Distance to MEI (m)[b]	Direction to MEI[b]
Isopleth 4	267,835	3,955	SE
Isopleth 5	4,966,529	2,185	SE
Isopleth 6	131,338	3,838	SE
Isopleth 7	222,993	3,618	ESE
Isopleth 8	2,187,390	2,406	SE
Isopleth 9	18,185	1,063	SE
Isopleth 10	1,124,776	2,625	SE
Isopleth 11	107,203	2,178	SE
Isopleth 12	11,518	2,379	ESE
Isopleth 13	64,337	2,465	ESE
Isopleth 14	379,920	2,967	SE
Isopleth 15	24,270	2,563	SE
Isopleth 16	285,832	2,996	SE
Isopleth 17	191,315	3,042	SE
Isopleth 18	83,574	3,126	SE
Isopleth 19	41,276	3,154	SE
Isopleth 20	11,221	3,172	SE

[a] All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

[b] From isopleth centroids.

Notes:

m	=	Meters
m^2	=	Square meters
MEI	=	Maximally exposed individual

Table 4-4

Uranium-233/234 Non-Point Source Model Input Data[a]

Isopleth No.	Area (m^2)	Distance to MEI (m)[b]	Direction to MEI[b]
Isopleth 1	3,444	3,954	SE
Isopleth 2	34,942	4,404	ESE
Isopleth 3	3,475	4,179	ESE
Isopleth 4	22,714	4,671	ESE
Isopleth 5	23,320	4,391	ESE
Isopleth 6	2,356	4,177	ESE
Isopleth 7	16,505	4,660	ESE
Isopleth 8	12,384	4,375	ESE
Isopleth 9	905	4,173	ESE
Isopleth 10	12,012	4,661	ESE
Isopleth 11	7,257	4,368	ESE
Isopleth 12	262	4,169	ESE
Isopleth 13	3,032	4,360	ESE

[a] All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

[b] From isopleth centroids.

Notes:

m	=	Meters
m^2	=	Square meters
MEI	=	Maximally exposed individual

Table 4-5

Uranium-235 Non-Point Source Model Input Data[a]

Isopleth No.	Area (m^2)	Distance to MEI (m)[b]	Direction to MEI[b]
Isopleth 1	13,336	4,376	ESE
Isopleth 2	1,008	4,173	ESE
Isopleth 3	8,033	4,369	ESE
Isopleth 4	270	4,170	ESE
Isopleth 5	2,513	4,360	ESE

[a] All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

[b] From isopleth centroids.

Notes:

m	=	Meters
m^2	=	Square meters
MEI	=	Maximally exposed individual

Table 4-6

Uranium-238 Non-Point Source Model Input Data[a]

Isopleth No.	Area (m^2)	Distance to MEI (m)[b]	Direction to MEI[b]
Isopleth 1	53	3,833	SE
Isopleth 2	1,171	3,585	SE
Isopleth 3	8,299	3,209	SE
Isopleth 4	7,254	3,320	SE
Isopleth 5	2,969	4,118	ESE
Isopleth 6	314	4,679	ESE
Isopleth 7	795	4,116	ESE

[a] All non-point sources were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity).

[b] From isopleth centroids.

Notes:

m	=	Meters
m^2	=	Square meters
MEI	=	Maximally exposed individual

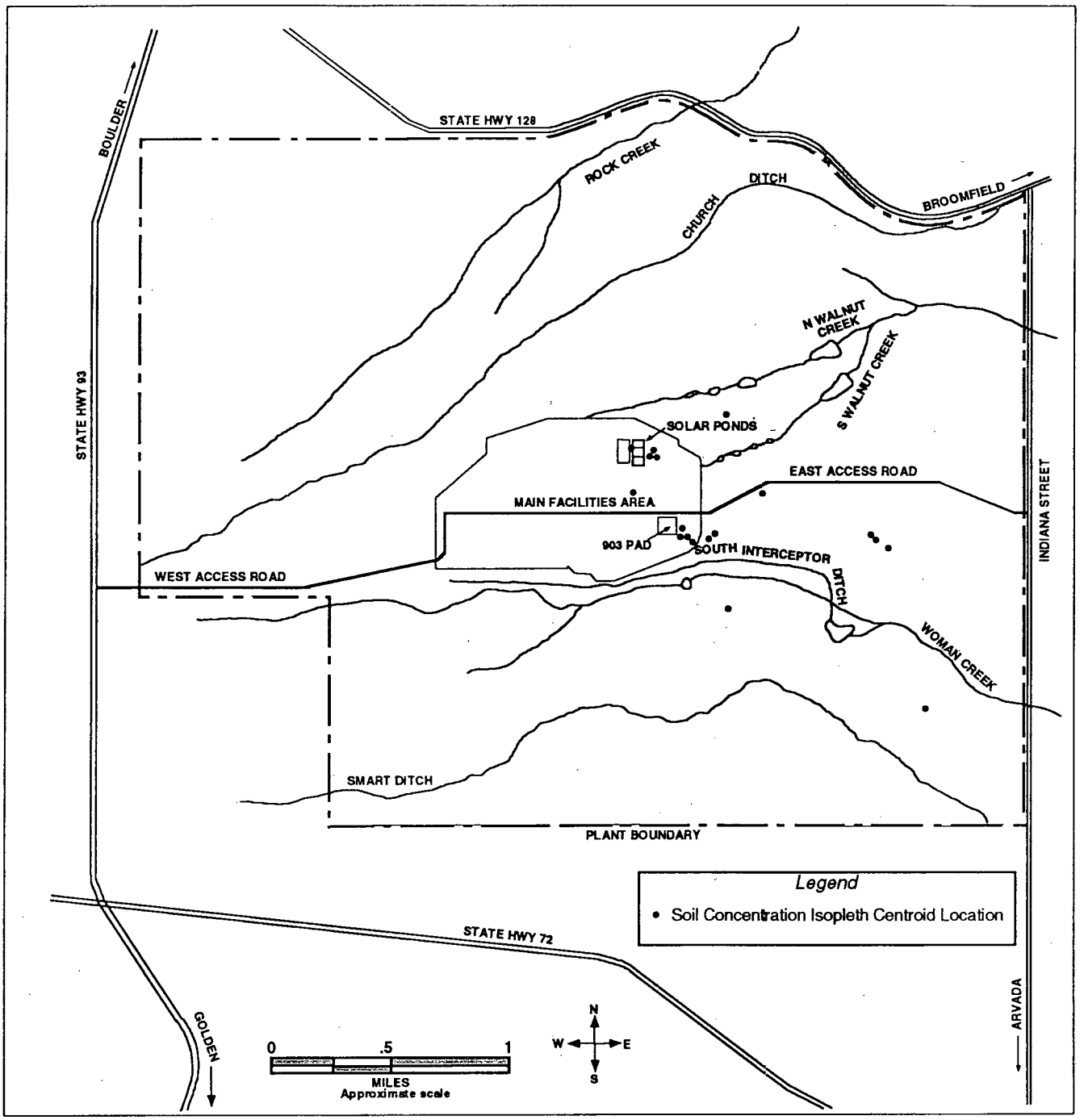


Figure 4-3. Soil Concentration Isopleth Centroid Locations for Americium-241

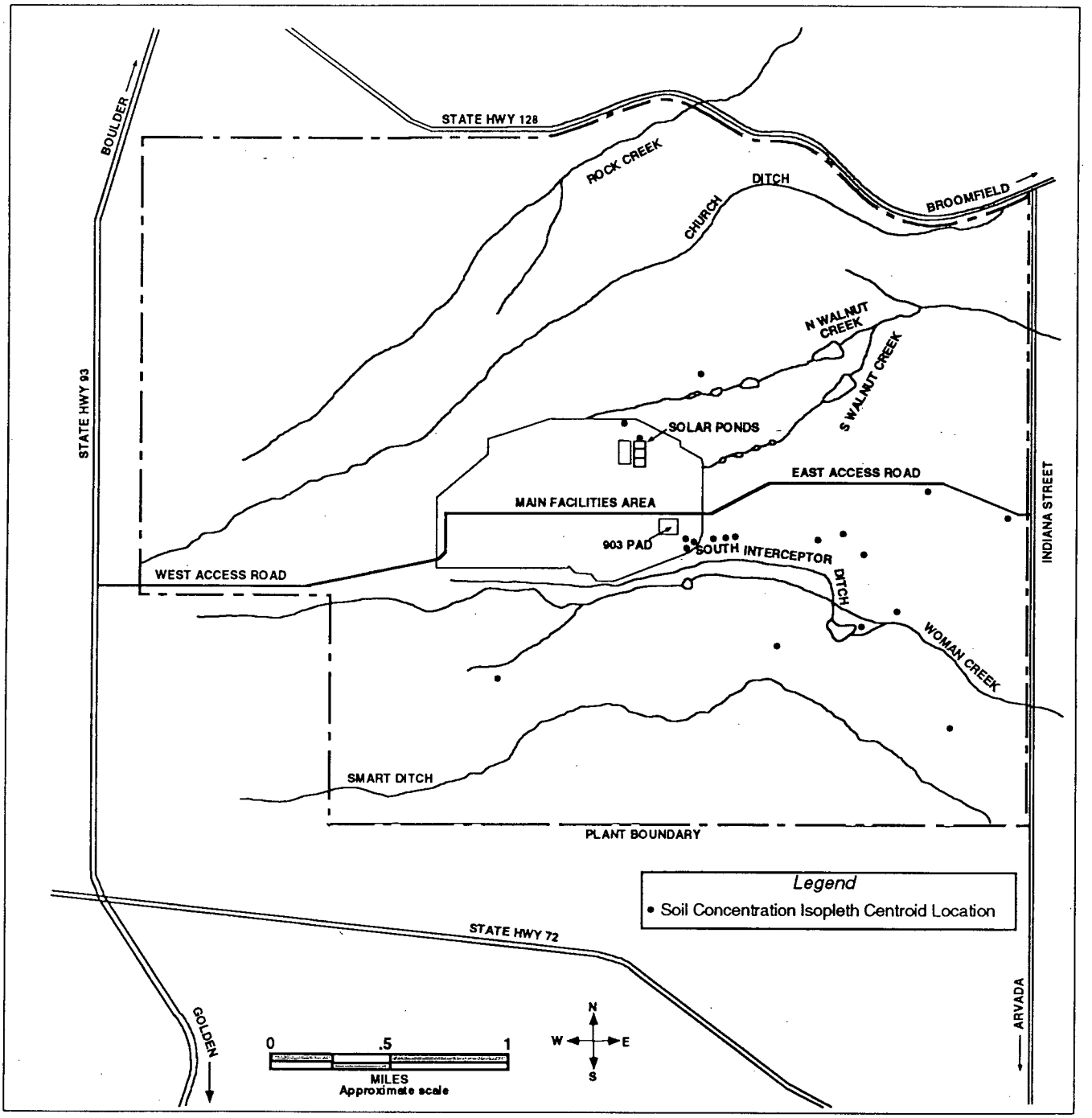


Figure 4-4. Soil Concentration Isopleth Centroid Locations for Plutonium-239 and Plutonium-240

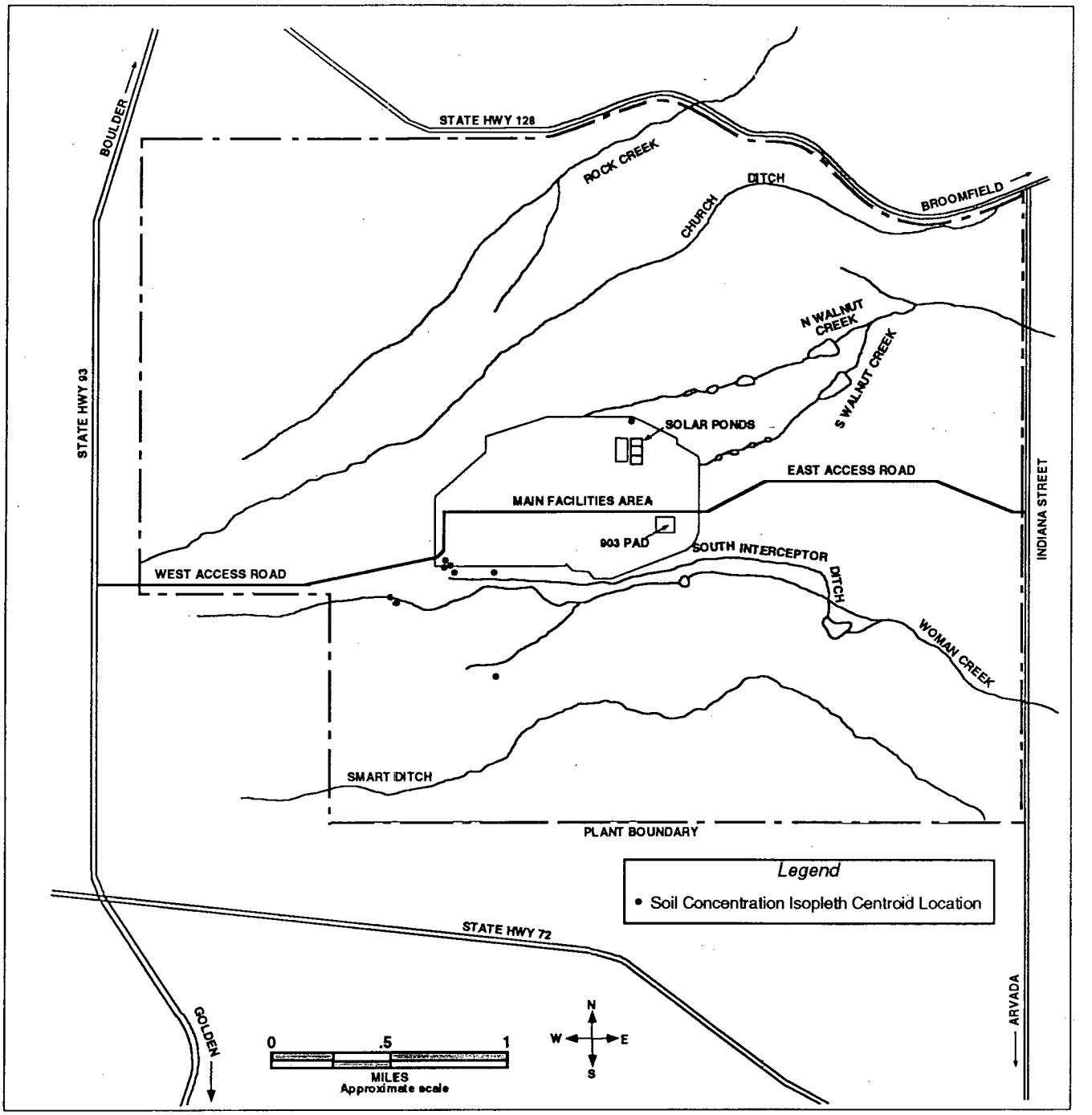


Figure 4-5. Soil Concentration Isopleth Centroid Locations for Uranium-233 and Uranium-234

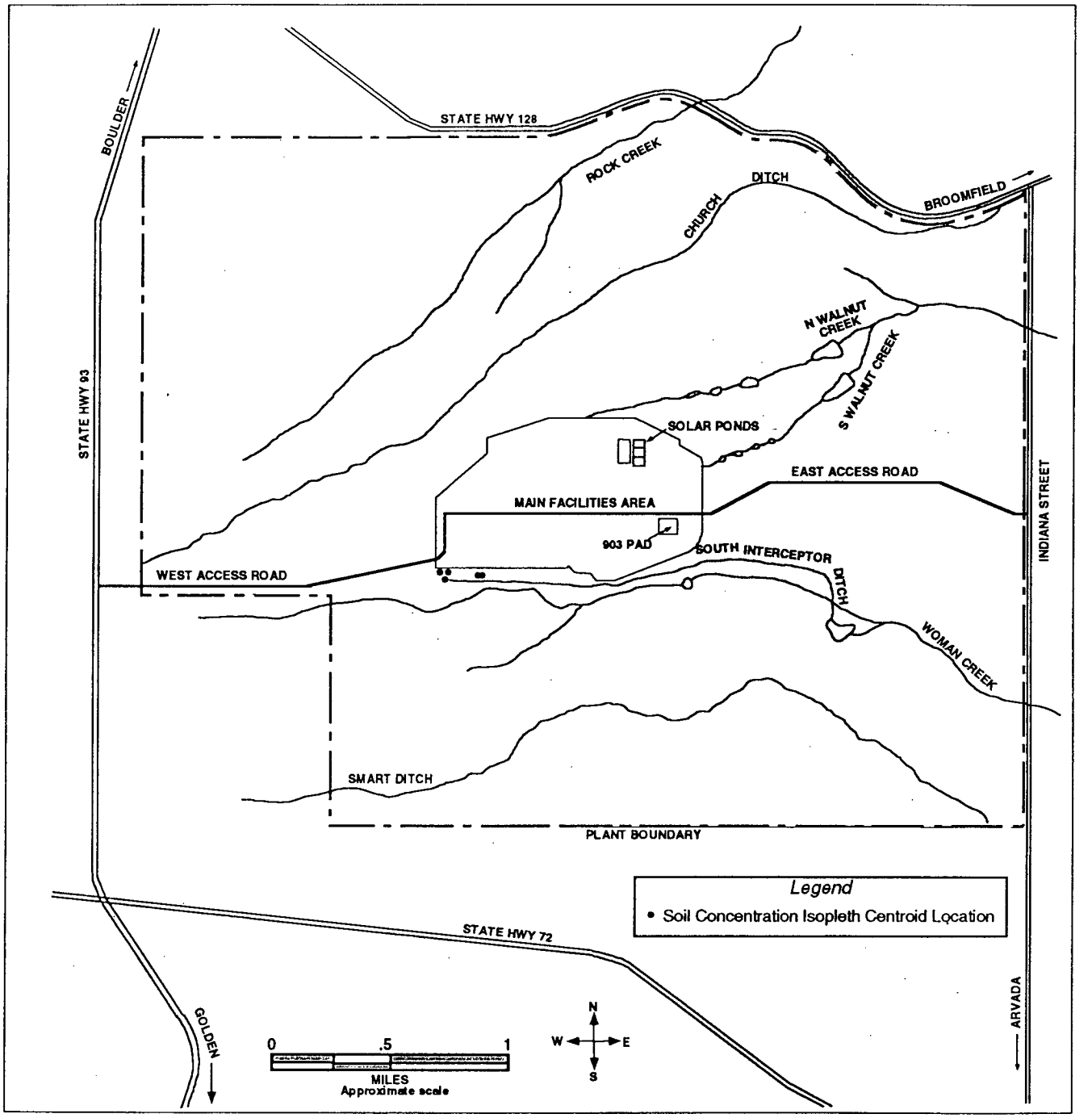


Figure 4-6. Soil Concentration Isopleth Centroid Locations for Uranium-235

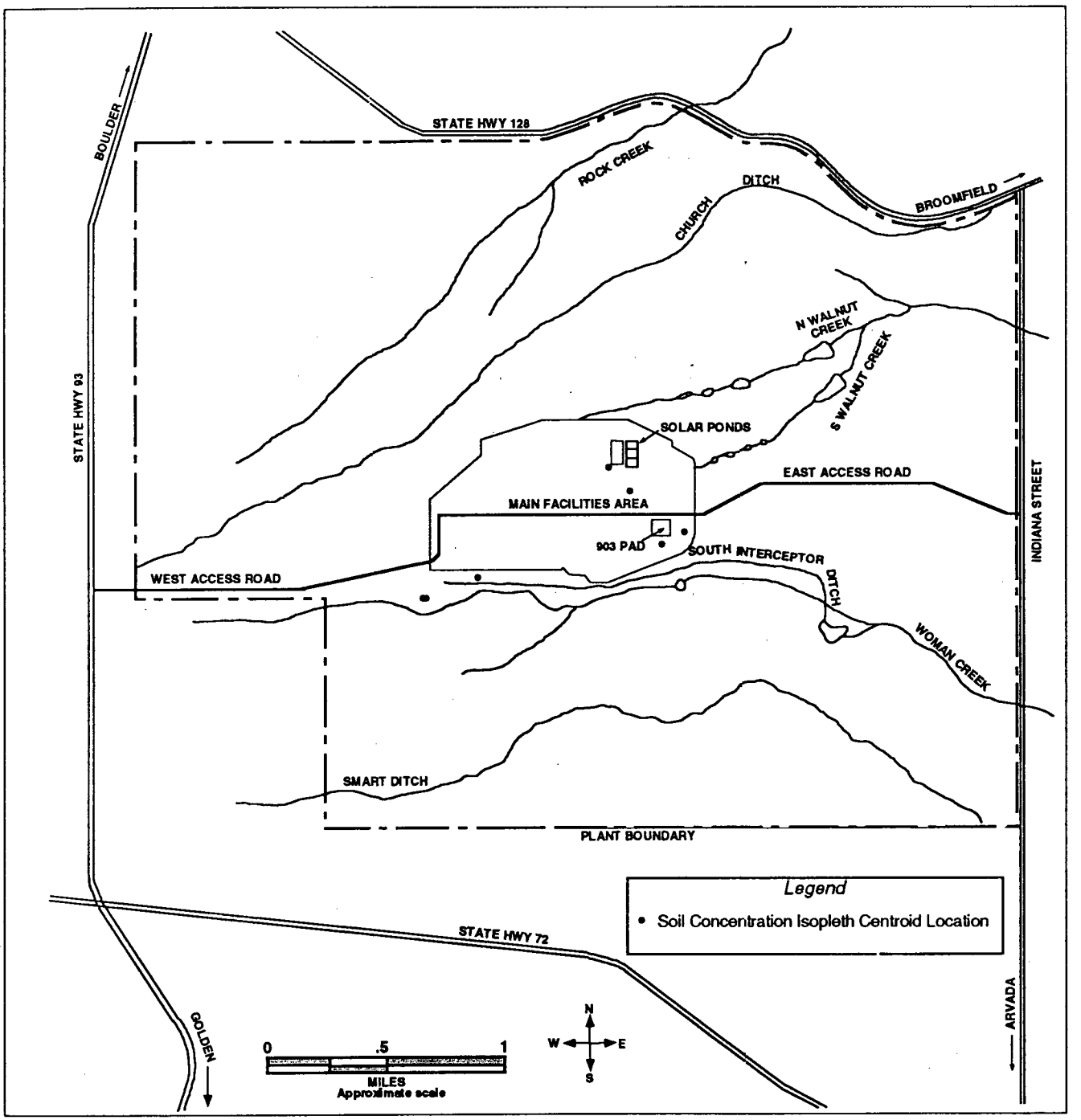


Figure 4-7. Soil Concentration Isopleth Centroid Locations for Uranium-238

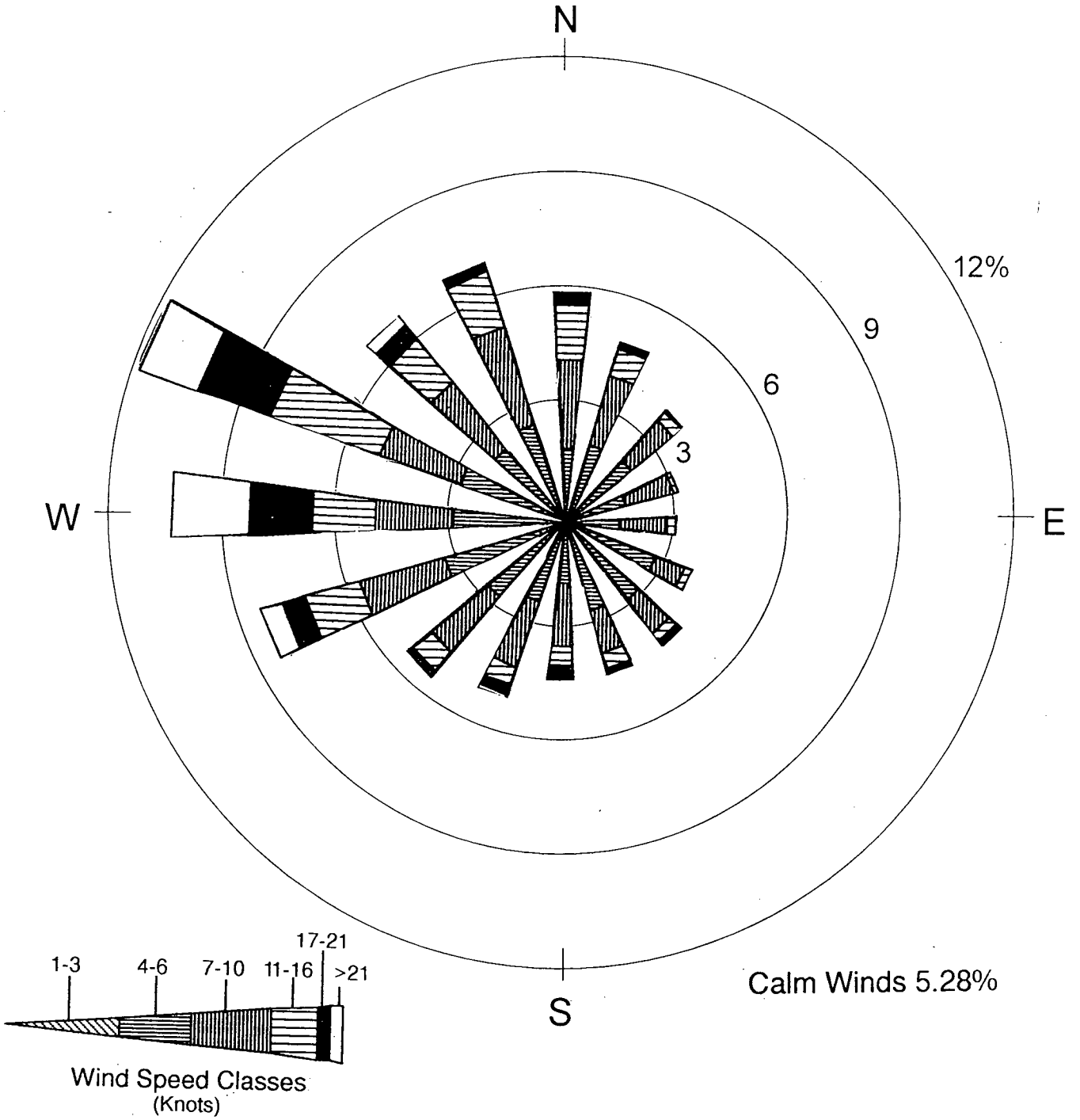


Figure 4-9. Wind Frequency Distribution for 1995

Table 4-7

Additional Meteorological Data for Model Input

Input	Value Used
Wind Data	From on-site tower at 10 m height
Annual Precipitation[a]	54.8 cm
Annual Average Temperature[b]	8.7 °C
Mixing Height[c]	1,405 m

[a] Total precipitation equivalent for 1995 (rainfall and snowfall).

[b] Average of monthly average temperatures.

[c] Average of annual morning and afternoon mixing heights for Denver from "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States," US EPA, Office of Air Programs, Research Triangle Park, NC, January 1972

Notes:

cm	=	Centimeter
m	=	Meter
°C	=	Degrees Celsius
US EPA	=	U.S. Environmental Protection Agency

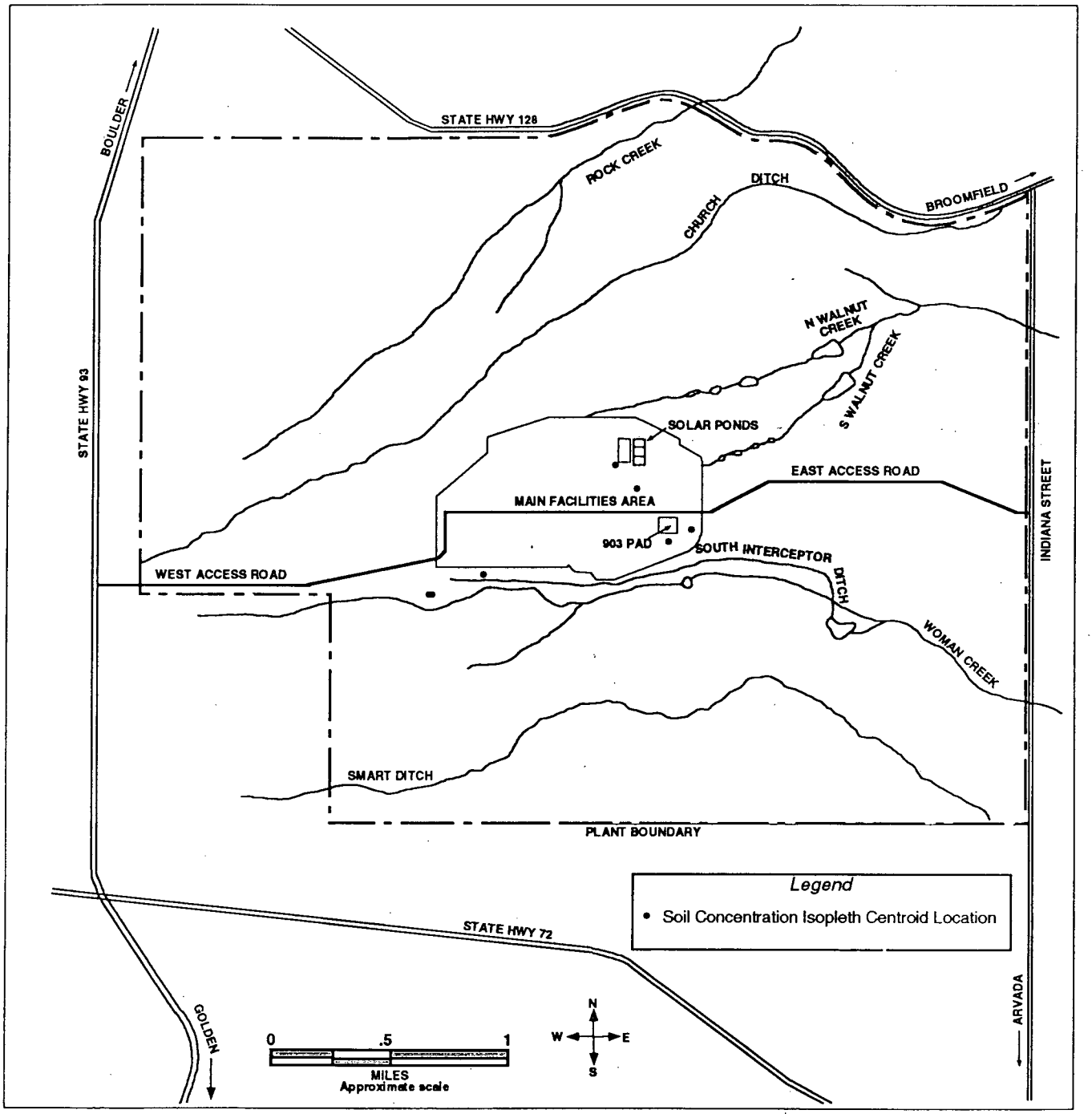


Figure 4-7. Soil Concentration Isopleth Centroid Locations for Uranium-238

the model and are shown in Table 4-8. Default values were also used for the origin of food products, as shown in Table 4-9.

The shortest distance between a Site radionuclide release point and farmland producing agricultural products is 720 m for beef cattle, 5,228 m for dairy cattle, and 1,063 m for cropland.

4.3 Compliance Assessment

The EDEs calculated for each modeled emission source were summed for each receptor and the MEI determined. The EDE for the MEI from 1995 Site operations is 0.0078 mrem/yr (0.000078 milliSieverts per year [mSv/yr]), which is well below the standard of 10 mrem/yr. The MEI is a residence located on the corner of 96th Street and Indiana Avenue, 3,900 m to the southeast of the center of the Site's industrialized area.

A graph portraying the contribution from each isotope to the EDE at the MEI location is shown in Figure 4-10. A chart showing the contribution to the EDE by source type is shown in Figure 4-11.

4.4 Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. (See 18 U.S.C. 1001.)

Keith Klein
Deputy Manager, Rocky Flats Field Office
Department of Energy

for

6/19/96
Signature Acting AM for Env Compl. Date

John A. Hill
Vice President, ER/WM &I
Kaiser-Hill Company, L.L.C.

John A. Hill 6/17/96
Signature Date

Table 4-8

Agricultural Data for Model Input

Input	Value Used
Source	Urban
Beef Cattle Density[a]	1.13 E-01 cattle/km^2
Milk Cattle Density[a]	3.50 E-03 cattle/km^2
Land Fraction Cultivated for Vegetable Crops[a]	1.39 E-02

[a] Model default values.

Note:

km^2 = Square kilometers

E# = x $10^{\#}$

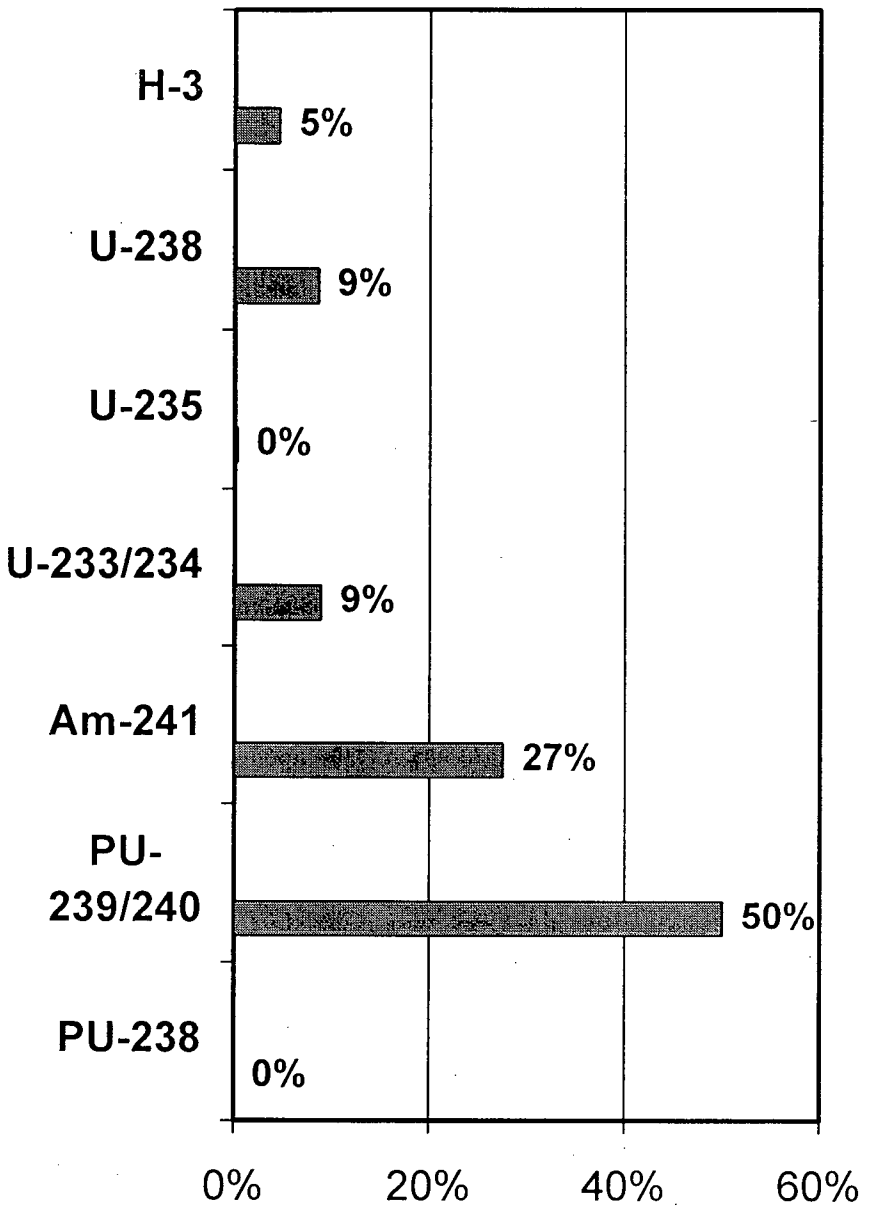
Table 4-9

Origin of Food Products

Origin	Food Product		
	Vegetable	Milk	Beef
Fraction From Home Produced[a]	0.076	0.0	0.008
Fraction From Assessment Area[a]	0.924	1.0	0.992
Fraction Imported[a]	0.0	0.0	0.0

[a] Model default values.

Figure 4-10.
Estimated Total Dose Equivalent by Isotope



Notes:

Am	=	Americium
H-3	=	Tritium
Pu	=	Plutonium
U	=	Uranium

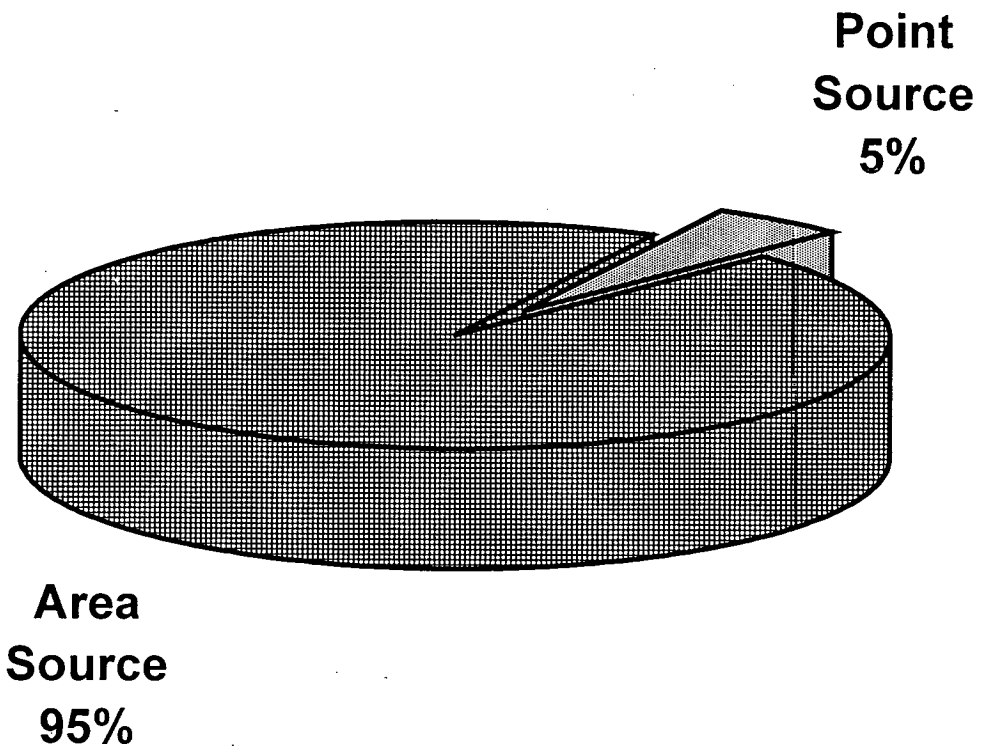


Figure 4-11.
Estimated Total Dose Equivalent by Source Type

5.0 SUPPLEMENTAL INFORMATION

The following information is provided pursuant to DOE guidance and is not required by 40 CFR 61, Subpart H, or Regulation No. 8, Part A, Subpart H, reporting requirements.

- There were no unplanned releases of radionuclides to the atmosphere from the Site during 1995.

- The collective dose was calculated with CAP88-PC using population figures that were adjusted from 1994 data based on regional growth information. The collective dose for the 1995 calendar year was 0.094 mrem/yr (0.00094 mSv/yr).

- 40 CFR 61, Subparts T and Q (Regulation No. 8, Part A, Subparts T and Q) are not applicable to this Site.

- Status of compliance with EPA effluent monitoring requirements: According to the Site Air Operating Permit Application submitted in 1995 (DOE, 1996), the Site is in compliance with all requirements of 40 CFR 61, Subpart H, and Regulation No. 8, Part A, Subpart H, with the exception of Section 61.93(b)(1) and 61.93(b)(2)(i).

  Compliance Plan for 61.93(b)(1): The Site is in compliance at 18 of 24 volumetric flow rate locations. There are six locations that are not in compliance because they fail to satisfy the siting criteria of 40 CFR 60, Appendix A, Reference Method 1 (Regulation No. 6, Part A, Appendix A, Reference Method 1). The six volumetric flow rate locations are scheduled to be modified to meet the siting criteria of 61.93(b)(1)(i).

  Compliance Plan for 61.93(b)(2)(i): Fifteen of 24 sampling sites comply with Reference Method 1 of Appendix A to 40 CFR 60 and Regulation No. 6, Part A. There are nine sampling locations at the Site that are not in compliance because they fail to satisfy siting criteria requirements of 61.93 (b)(2)(i).

  Representative samples of the effluent stream are withdrawn continuously from each monitored sampling site following the guidance presented in ANSI N13.1-1969. Site air monitoring personnel believe that the current monitoring system is, and always has been, in compliance with the required monitoring protocols. Between approximately 1990 and 1994, the Site provided information requested by EPA, Region VIII, including information requested as part of a 1992 Administrative Compliance Order, to obtain an official determination as to whether the Site was in compliance with the required monitoring protocols. No final compliance determination has been issued by EPA, Region VIII, although, in a March 4, 1992

Environmental News release, EPA stated that "in the interim, EPA believes public health is being protected. Air sampling systems at the facility and air monitoring equipment surrounding the plant continue to provide information indicating that potential estimated exposures to area residents are hundreds of times below limits set in the National Emissions Standards for Hazardous Air Pollutants (NESHAPS)."

In the absence of an official determination, the Site offered, and Region VIII approved, the installation of an alternative shrouded probe monitoring methodology approved by both DOE headquarters (HQ) and EPA HQ. A schedule has been established for installation of this methodology at locations that require continuous monitoring. Engineering of the new shrouded probe sampling systems is underway, with installation to be completed by December 1997. The nine sampling locations that are noncompliant with 61.93(b)(2)(i) are scheduled to be modified to meet the alternate shrouded probe method during this shrouded probe sampling system upgrade project.

6.0 REFERENCES CITED

U.S. Department of Energy. Radionuclide Air Emissions Annual Report for Calendar Year 1994. June, 1995.

U.S. Department of Energy. Rocky Flats Environmental Technology Site, Air Operating Permit Application. January, 1996.

U.S. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, NC. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. January, 1972.

APPENDIX A

RADIOACTIVE MATERIALS ASSOCIATED WITH ROCKY FLATS

ROCKY FL[illegible] REPORT

RADIO[illegible] [illegible]S

A[illegible]OCIATED [illegible]

[illegible]OCKY [illegible]

[illegible]ober 31, [illegible]

[illegible] Brito [illegible]

Source [illegible] Program [illegible]

[illegible]/966-[illegible]

Reviewed for Classification/UCNI

By [illegible]

Date [illegible]

A. RADIOACTIVE MATERIALS HANDLED IN KILOGRAM QUANTITIES

1. Plutonium

Isotopic Composition of Rocky Flats Plutonium

Isotope	Relative Weight (percent)	Specific Alpha Activity (Curies/gram)	Specific Beta Activity (Curies/gram)	Relative Activity (Curies/gram)[a]
Pu-238	0.01	17.01	- - -	0.00171
Pu-239	93.79	0.0622	- - -	0.05834
Pu-240	5.80	0.228	- - -	0.01322
Pu-241	0.36	- - -	103.5	0.37260
Pu-242	0.03	0.00393	- - -	1.18×10^{-6}
Am-241	[b]	3.42	- - -	- - -

[a] Relative activity is obtained by multiplying the percent by weight by the specific activity. The total activity for the Plutonium Isotopes is: Alpha, 0.0732 curies/gram; and Alpha plus Beta, 0.446 curies/gram.

[b] Am-241 is a radioactive decay product of Pu-241.

2. Enriched Uranium

Common Name: Oralloy
Normal Isotopic Composition: >90% U-235

3. Depleted Uranium

Common Names: Tuballoy, D-38, U-238
Normal Isotopic Composition: <0.71%, U-235

4. Americium (Am-241)

Am-241 is a radioactive decay product of Pu-241.

5. Natural Uranium (Thorium and Uranium-233)

Rocky Flats has both the capability and potential to handle these in kilogram quantities. Some of these materials have been handled in the past.

B. RADIOACTIVE MATERIALS HANDLED IN GRAM QUANTITIES (<1Kg)

Curium-244
Neptunium-237
Uranium-233
Plutonium-238,-242

These radioisotopes may be handled at Rocky Flats primarily for research and analytical activities.

C. RADIOISOTOPES UTILIZED AT ROCKY FLATS AS REGISTERED AND/OR MISCELLANEOUS SOURCES

1. Registered Sources (Twice-Yearly Leak Test and Physical Audit)

Sealed solids >10 μCi
Plated solids >1 μCi
Liquids > 10^{-3} μCi

Americium	(Am-241)	Iridium	(Ir-192)
Antimony	(Sb-124)	Iron	(Fe-55)
Barium	(Ba-133)	Nickel	(Ni-63)
Cadmium	(Cd-109)	Plutonium	(Pu-238,-239, -240,-244)
Californium	(Cf-252)	Promethium	(Pm-147)
Cesium	(Cs-137)	Radium	(Ra-226)
Cobalt	(Co-57,60)	Selenium	(Se-75)
Europium	(Eu-152)	Sodium	(Na-22)
Hydrogen (Tritium)	(H-3)	Strontium	(Sr-90)
		Thorium	(Th-228)
		Uranium	(U-234, -235,-238)

2. Miscellaneous Sources

Sealed solids < 10 μCi
Plated solids < 1 μCi
Liquids $<10^{-3}$ μCi
Analytical stock solutions

Alumium	(Al-26)
Americium	(Am-241,-243)
Antimony	(Sb-125)
Argon	(Ar-39)
Barium	(Ba-133)
Beryllium	(B-7)
Bismuth	(Bi-207,-210)
Cadmium	(Cd-109)
Californium	(Cf-252)
Carbon	(C-14)
Cesium	(Cs-137)
Chlorine	(Cl-36)
Cobalt	(Co-57,-60)
Curium	(Cm-244)
Europium	(Eu-152)
Holmium	(Ho-166m)
Hydrogen (Tritium)	(H-3)
Iodine	(I-129,-131)
Iron	(Fe-55)
Krypton	(Kr-85)
Lead	(Pb-210)
Manganese	(Mn-54)
Mercury	(Hg-203)
Neptunium	(Np-237)
Plutonium	(Pu-236,-238,-239 -240,241,242)
Polonium	(Po-210)
Promethium	(Pm-147)
Radium	(Ra-226)
Ruthenium	(Ru-106)
Selenium	(Se-75)
Silver	(Ag-110m)
Sodium	(Na-22)
Strontium	(Sr86-90)
Technetium	(Tc-99m)
Thallium	(Tl-204)
Thorium	(Th-228,-230,-232)
Tin	(Sn-113)
Uranium	(U-232, -234, 235, -236,-238)
Yttrium	(Y-88,-90)
Zinc	(Zn-65)

D. RADIUM SOURCES HANDLED AND STORED AT ROCKY FLATS

AS/RS*	EG&G ID	Nuclide	Location	Original Activity (µCi)
AS	2934	Ra-226	119	0.09
RS	100	Ra-226	707	6.00000
RS	138	Ra-226	776	6.00000
RS	3695	Ra-226	881	6.26
RS	866	Ra-226	881	10.95
RS	810	Ra-226	771	11.26000
RS	409	Ra-226	371	12.5
RS	196	Ra-226	771	16
RS	23	Ra-226	777	4500
RS	146	Ra-226	777	4500

* *AS = Accountable Source*
RS = Registered Source

APPENDIX B

EFFLUENT INFORMATION SYSTEM (EIS) DATA

Summary table for the EIS-ODIS report
1995-Release (Ci)

95_ODIS LOCATION	ODIS LOCATION CODE	N	Effluent Volume (m^3)	Pu-238	Pu-239	Am-241	U-233+4	U-238	H-3	Be (Grams)
)7-101	AFGHB707005	11	1.097E+07	-8.438E-13	3.961E-11	-2.045E-11	6.142E-11	1.165E-10	-	0.000498
)7-102	AFGHB707006	11	1.471E+07	-1.391E-11	7.832E-11	-2.008E-11	9.560E-11	2.532E-10	6.927E-02	0.000395
707-105	AFGHB707003	11	9.319E+07	-1.306E-11	6.107E-10	3.688E-10	5.830E-09	5.937E-09	-	0.003547
707-106	AFGHB707001	11	2.565E+07	8.794E-12	1.943E-10	1.485E-11	1.219E-10	4.858E-10	-	0.000954
707-107	AFGHB707004	11	1.772E+08	-1.325E-10	7.505E-10	2.228E-10	1.067E-08	1.196E-08	-	0.034919
707-108	AFGHB707002	11	1.092E+08	-3.968E-11	1.426E-09	1.793E-09	4.941E-09	5.575E-09	-	0.017972
707-R21	AFGHI707001	9	4.515E+08	6.531E-13	4.342E-09	1.696E-09	7.826E-09	1.626E-08	-	0.020373
707-R22	AFGHI707002	9	4.515E+08	-2.060E-10	2.331E-09	2.756E-09	1.624E-08	2.219E-08	-	0.021016
707-R23	AFGHI707003	9	4.515E+08	1.252E-09	5.081E-09	2.736E-09	8.588E-09	1.309E-08	-	0.020587
707-R24	AFGHI707004	9	4.515E+08	2.516E-10	4.405E-09	1.322E-09	5.359E-09	1.236E-08	-	0.018121
707-R25	AFGHI707005	9	4.515E+08	4.703E-09	2.237E-09	1.129E-09	1.407E-08	1.807E-08	-	0.015869
707-R26	AFGHI707006	9	4.515E+08	8.509E-10	2.122E-09	3.192E-09	8.319E-09	2.463E-08	-	0.017800
707-R27	AFGHI707007	9	4.515E+08	1.063E-09	6.999E-09	-2.035E-10	-2.504E-08	-2.343E-08	-	0.016770
707-R45	AFGHI707008	9	4.515E+08	1.195E-11	3.466E-09	2.666E-09	1.429E-08	1.562E-08	-	0.017907
707-R46	AFGHI707009	8	4.515E+08	1.269E-10	2.975E-09	7.544E-10	1.703E-08	1.500E-08	-	0.019730
779-782	AFGHF779002	12	5.959E+08	-1.901E-10	3.089E-09	2.978E-09	3.919E-08	4.311E-08	1.614E+00	0.112065
779-729	AFGHF779001	12	1.457E+08	3.255E-12	1.144E-09	6.599E-11	1.775E-09	4.699E-10	-	0.027441
776-201	AFGHE776003	12	6.131E+06	-7.156E-12	6.614E-11	4.632E-13	6.750E-11	1.058E-10	-	0.000821
776-202	AFGHE776008	12	6.278E+07	1.191E-11	1.061E-09	9.984E-11	5.694E-10	1.400E-09	-	0.001786
776-204	AFGHE776005	12	1.623E+08	-1.193E-10	1.980E-09	5.808E-10	1.166E-08	1.325E-08	-	0.034411
776-205	AFGHE776004	12	8.540E+07	-3.456E-11	5.529E-10	5.297E-11	4.871E-10	1.008E-09	3.219E-01	0.015679
776-206	AFGHE776002	12	8.091E+07	4.407E-11	1.172E-09	6.945E-11	1.546E-09	2.066E-09	1.061E+00	0.002704
776-207	AFGHE776009	12	5.984E+07	-1.067E-10	5.271E-10	5.020E-11	8.741E-10	1.618E-09	-	0.001946
776-250	AFGHE776001	18	3.830E+08	-1.118E-10	2.083E-09	2.045E-09	7.856E-09	1.254E-08	1.895E+00	0.012696
776-251	AFGHE776006	9	3.327E+08	-7.314E-11	1.824E-09	2.320E-09	2.969E-08	3.576E-08	1.307E+00	0.063007
776-252	AFGHE776007	9	8.803E+07	-1.275E-10	5.984E-10	3.818E-10	1.361E-09	7.934E-10	-	0.003115
559-561	AFGHA559001	12	5.732E+08	-7.576E-11	2.468E-09	7.033E-10	2.949E-08	3.514E-08	-	0.020452
778-LDY	AFGHH778001	9	2.146E+08	8.291E-09	2.382E-07	1.906E-08	2.100E-08	1.050E-07	-	0.008309
'1-MAI	AFGHC771001	11	2.008E+09	2.567E-09	1.524E-07	3.093E-08	1.038E-07	1.122E-07	-	0.435255
'1-CMA	AFGHC771002	9	7.534E+07	8.525E-11	1.904E-09	9.804E-10	2.953E-09	3.463E-09	-	0.001781
771-CRM	AFGHC771005	8	9.163E+07	1.841E-09	1.683E-07	7.022E-09	6.740E-09	5.206E-09	-	0.003208
774-202	AFGHD774001	12	7.545E+07	1.692E-11	2.591E-10	1.051E-10	-7.839E-10	2.781E-11	-	0.002149
444-MAI	AFGHN444004	9	1.493E+09	--	--	--	8.264E-08	8.729E-08	-	0.084560
444-D05	AFGHN444003	9	1.580E+08	--	--	--	-1.679E-08	-1.283E-08	-	0.024691
447-MAI	AFGHO447001	9	7.598E+08	--	--	--	1.195E-07	1.309E-07	-	0.121718
865-EEE	AFGHP865001	9	4.103E+08	--	--	--	5.017E-08	5.678E-08	-	0.062912
865-WWW	AFGHP865002	9	6.800E+08	--	--	--	1.283E-07	1.310E-07	-	0.109082
886-875	AFGHS886001	9	1.168E+08	1.248E-10	5.619E-10	3.889E-10	4.697E-09	7.504E-09	-	0.003619
881-ANX	AFGHQ881002	0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-	0.000000
881-MAI	AFGHQ881001	36	3.934E+09	-4.334E-10	2.184E-08	2.700E-08	3.241E-07	3.177E-07	-	0.705527
883-AAA	AFGHR883001	9	7.811E+08	--	--	--	8.230E-08	7.464E-08	-	0.117439
883-BBB	AFGHR883002	9	1.089E+09	--	--	--	7.427E-08	8.383E-08	-	0.174182
883-CCC	AFGHR883003	9	2.361E+08	--	--	--	2.342E-08	3.886E-08	-	0.042942
889-MAI	AFGHT889001	9	8.617E+07	2.450E-10	1.133E-09	6.627E-10	-8.272E-09	-7.900E-09	-	0.011226
991-985	AFGHU991001	9	1.352E+08	2.326E-10	1.694E-08	1.782E-08	1.887E-08	6.487E-09	-	0.005287
374-MAI	AFGHJ374001	12	3.468E+08	-2.682E-11	3.996E-09	1.936E-09	-6.957E-09	-1.012E-09	-	0.062231
991-MAI	AFGHU991002	9	1.070E+08	5.821E-11	4.304E-10	3.458E-10	6.534E-09	6.658E-09	-	0.002594
371-NNN	AFGHC371001	24	5.636E+08	1.343E-10	6.657E-09	1.624E-09	3.343E-08	3.706E-08	-	0.017193
371-SSS	AFGHC371002	12	3.204E+08	-4.197E-11	2.733E-09	6.876E-10	1.792E-08	2.166E-08	-	0.010756
374-SPD	AFGHD374002	9	8.930E+07	1.208E-10	3.701E-09	2.122E-09	4.842E-09	5.717E-09	-	0.002987
RF Plant		540	2.084E+10	2.029E-08	6.726E-07	1.384E-07	1.286E-06	1.496E-06	6.269E+00	2.5322326

APPENDIX C

RESUSPENSION OF SOIL PARTICLES FROM ROCKY FLATS CONTAINING PLUTONIUM PARTICULATES

RESUSPENSION OF SOIL PARTICLES FROM ROCKY FLATS CONTAINING PLUTONIUM PARTICULATES

G. Langer

Environmental Management
Air Quality & Chemical Tracking Division

EG&G Rocky Flats, Inc.
P. O. Box 464
Golden, CO 80402-0464

October 29, 1991

George H. Setlock

Reviewed for Classification/UCNI
By: George Setlock UNC
Date: October 29, 1991

EG&G ROCKY FLATS

EG&G Rocky Flats

GHS-0070-91

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EXECUTIVE SUMMARY

This report presents an overview of research conducted at the Rocky Flats Plant (RFP) on the resuspension of soil particles from soil contaminated with plutonium (Pu) in the area called the "903 Field." This field is adjacent to and directly east of a former oil drum storage area which in 1969 was paved with asphalt and designated the "903 Pad." The 903 Field is a source of airborne Pu, due to wind erosion, and has been studied since 1970 for the resuspension rate of Pu particles. The following processes were considered:

- saltation (wind erosion of bare soil);
- wind resuspension of particles from grass blades;
- rain splash; and
- mechanical disturbances and grass fires.

Results indicate wind resuspension from bare soil seems to be minimal, while resuspension from grass appears to be the dominant process. Additionally, rain splash was also found to be a significant resuspension process. Over 90 percent of the resuspended Pu from the 903 Field is associated with soil and grass litter particles larger than 3 μm. The airborne radioactivity is roughly proportional to the mass of particles collected. Resuspension of respirable particles from the field is very limited; this respirable concentration at the field is about the same as that due to nuclear fallout in and around the Denver area. Maximum transport of the Pu extends to 1.5 km from the 903 Field. The release of Pu is parameterized by a resuspension factor of 5×10^{-11} m^{-1} and a resuspension rate of 2×10^{-12} sec^{-1}. The total resuspension is very low, estimated at ~200 μCi/yr. For a typical respirable particle concentration of 0.01 fCi /m^3* of Pu-239 near the 903 Field, the Pu collected was equivalent to one, 1-μm particle per month, using a sampling rate of 1.1 m^3/min.

* 1 fCi = 10^{-15} Ci

INTRODUCTION

Concern over public health in regards to the 903 Field, located adjacent to a former outdoor drum storage area for waste oil, is recognized by RFP. The plant has been monitoring this area since the first oil drum leaks were discovered 30 years ago. The waste oil in these drums contained residue particles less than 3 μm in size of Pu from machining operations. Removal of the drums began in 1967 and the area was partially remediated and subsequently covered with an asphalt pad in 1969. During this period and continuing through the present, air at the 903 Field adjacent to the pad and in various locations around the Denver area (Figure 1) is continuously monitored for airborne Pu/soil particles by a network of surveillance air samplers. In the discussions that follow, it should be kept in mind that the Pu is attached to host soil particles that range in size from a few micrometers to millimeters. This is due to the nature of the original contamination process.

At no time since the completion in 1971 of the drum storage clean-up has Pu concentration exceeded the DOE "Derived Concentration Guide" of 20 fCi/m^3, either at the source area or in the surrounding community. In fact, it can be noted the concentration of respirable Pu particles at the 903 Field is near background levels found in the Front Range area of Colorado. Taking into account all significant pathways of human Pu intake, exposure to Pu at the 903 Field is well below EPA proposed guidelines (EP78, p221)*. The average total radioactivity concentration of airborne Pu at the plant boundary is 0.05 fCi/m^3.

The 903 Pad and Field are scheduled for further investigation and remediation in the future. The alpha radioactivity in the 903 Field soil is much less than EPA proposed guideline levels. The alpha radioactivity from RFP waste that has entered the environment amounts to a few curies, while waste tailings (uranium and thorium) from mining activity amount to a few thousand curies in an area in downtown Denver (KA84, p130). A synopsis is provided in this report of RFP research on the resuspension of Pu particles from the 903 Field. This research included:

- extent and radioactivity characterization of the source area;
- consideration of all feasible processes of resuspension; and
- investigation of the subsequent transport of the airborne particles according to their size and radioactivity category.

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* The last part of the literature citation, following the "p", indicates the page number at which the information will be found.

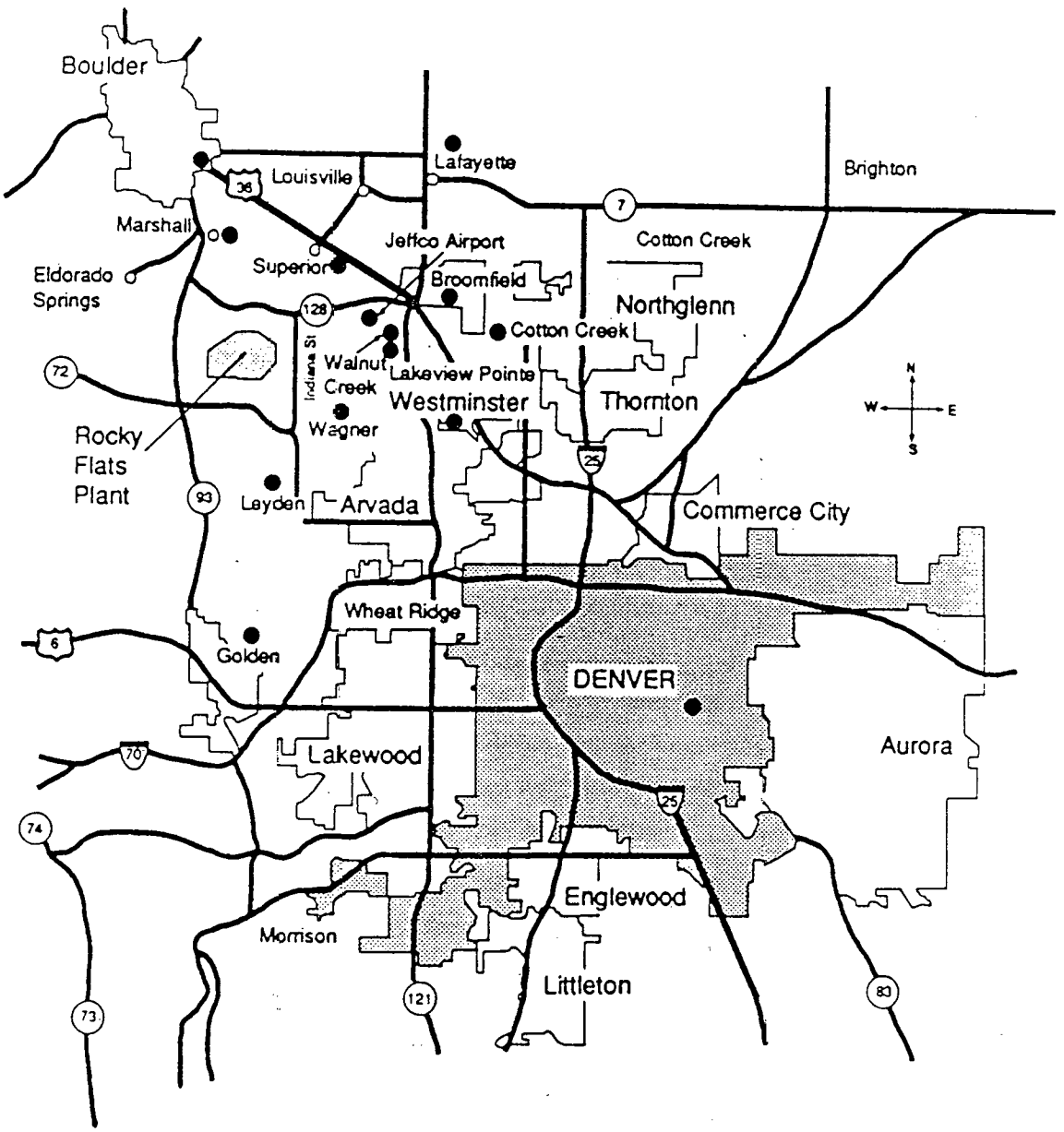

Figure 1. Area Map and Locations of RFP Community Samplers

SOURCE AREA AND SOURCE ACTIVITY

The area now known as the 903 Pad, after removal and off-site shipment of oil-covered surface rocks, was covered with gravel and then asphalt in 1969 to immobilize Pu-contaminated soil particles (Figure 2). However, during site preparation for the asphalting, occasional high winds swept across the uncovered area. Some dust was generated and much of it settled a short distance to the east of the site towards the plant site security fence. This area near the security fence is designated the 903 Field and has been covered with off-site topsoil. Vegetation has also been re-established. During the stabilization process fugitive Pu particles in the sub-surface soil were mixed into approximately 20 cm of new topsoil. This allows the possibility that some Pu particles could be resuspended, due to water or wind erosion. Therefore, access to the area is restricted and the ambient air in this area is continuously sampled by RFP for plutonium.

It should be noted that mine tailings from radium extraction, as found in some locations within the city of Denver, and mine tailings used in Grand Junction for home construction pose greater health hazards than the Pu contamination present in the 903 Field. Mine tailings release radon gas, which is difficult to immobilize, and the radon decay products become attached to respirable dust particles. The RFP Pu particles are relatively immobile and require extensive force to become airborne, which results mostly in particles too large (> 10-μm) to be inhaled (HA80a, p216). Once the small (<3-μm) Pu particles in the waste oil were immobilized by attachment to soil particles they became very difficult to separate, due to interatomic, attractive surface forces.

Figure 2 also shows the distribution of Pu in soil at and near the plant as determined by the Atomic Energy Commission (AEC) Health and Safety Laboratory (HASL) (RF3115, p14). The amount of Pu that leaked from the drums throughout their existence in the 903 Pad area was estimated in 1971 as 6.1 Ci or 86 g (SE71, p6; EI80, p2-73) based on the amount of oil leaked and Pu content of the oil. Nearly 4.0 Ci are now immobilized under the asphalt pad. A detailed ground gamma survey (RF3689, p18) for the Am-241 associated with the Pu indicated that approximately a total of 1.2 Ci of Pu exists in the 903 Field area west of the perimeter fence and bounded to the west by the 903 Pad. This survey was made after the removal in 1978 of soil containing an estimated 0.5 Ci of Pu-239, along the hill crest on the southern edge of the 903 Field. Another 0.67 Ci of Pu exists on the east side of the security fence in a small, localized area. Figures 3 and 4 illustrate this ground Am-241

gamma survey. These regions of high Pu soil concentrations are considered the source area for chronic release of Pu from RFP and this soil will likely be removed in the future once an acceptable regulatory framework has been worked out.

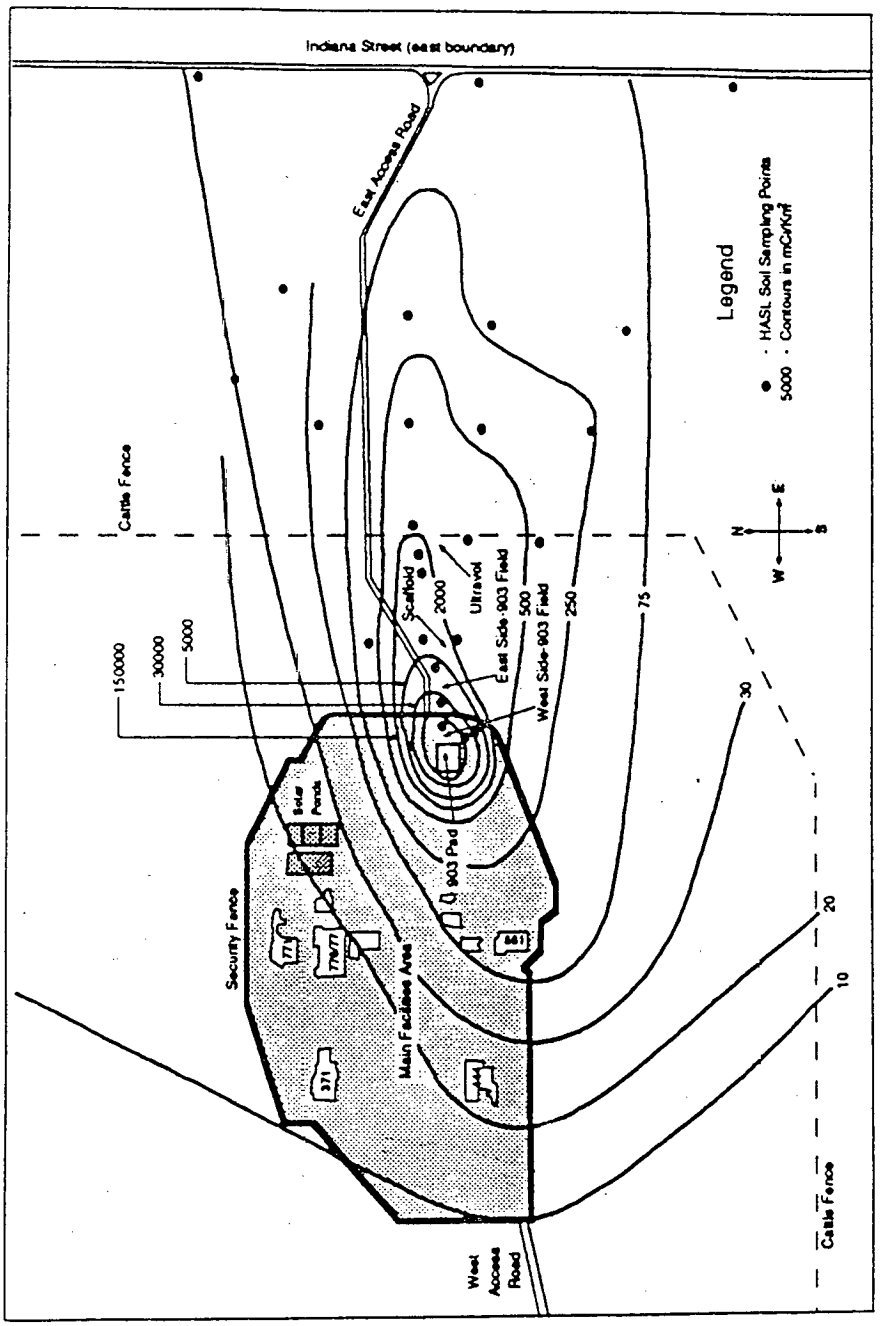

Figure 2. Plutonium-239 Deposition Contours in Millicuries Per Square Kilometer, According to HASL

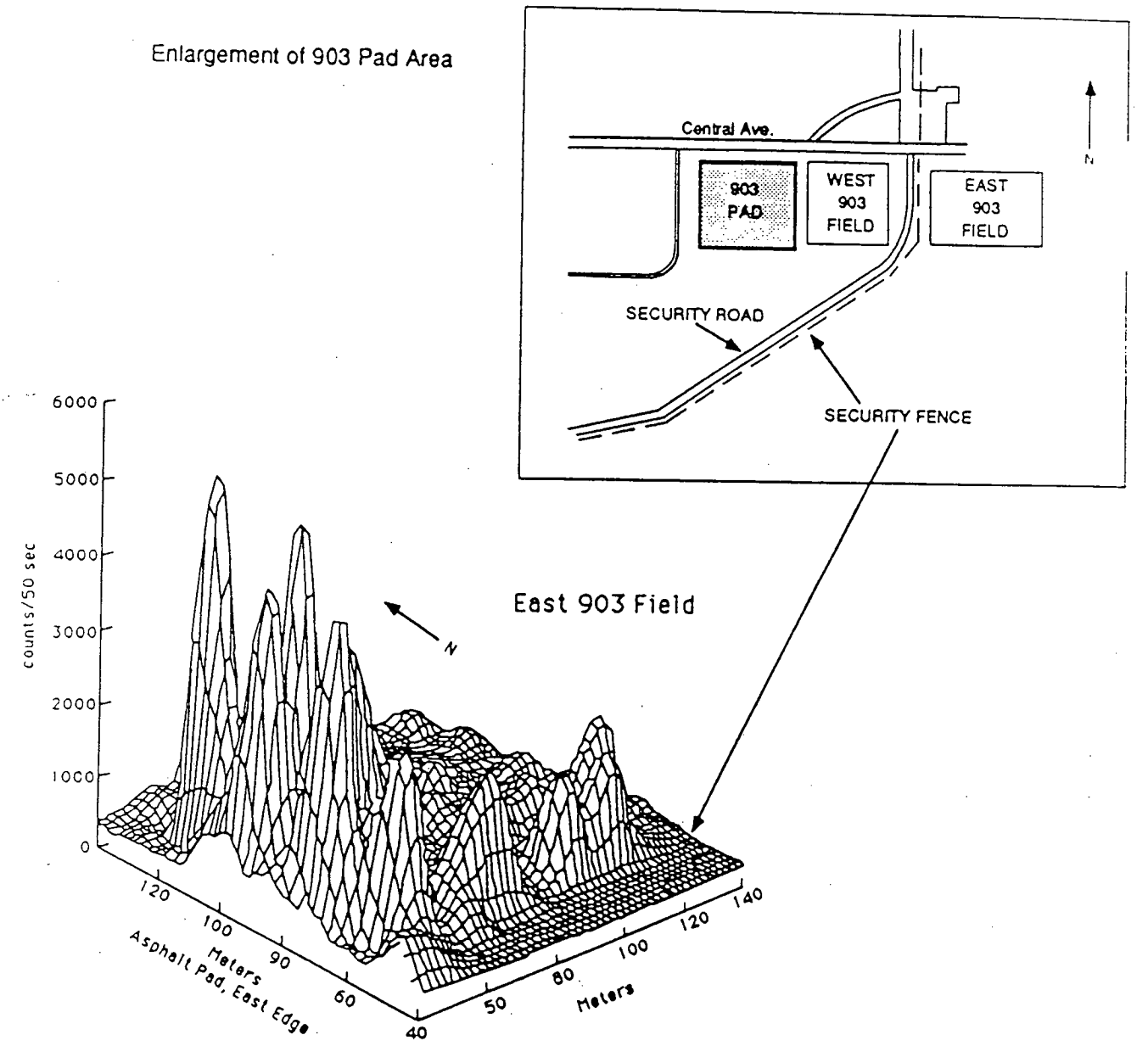

Figure 3. Three-deminsional Plot of Gamma Activity from Survey of West Side of 903 Field

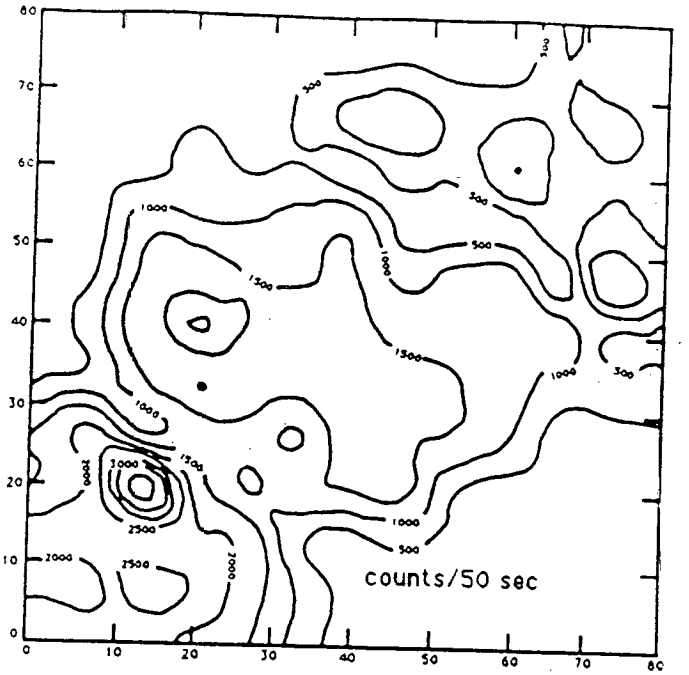

Figure 4. Contour Plot of Gamma Activity from Survey of East Side of 903 Field

P. W. Krey, in "Remote Plutonium Contamination and Total Inventories from Rocky Flats" (KR76, p214) has estimated, based on limited samples, that in addition to the Pu in the 903 Field there is another 3.4 Ci spread out over a wider region. This region, with near fallout Pu levels, extends east and southeast from the security fence. This would indicate that, based on a material balance, more than 9 Ci Pu-239 leaked from the drums instead of the 6.1 Ci estimated in 1971 and a total of about 5 Ci were resuspended from the drum storage area. Once past Indiana Street, the current eastern boundary of the plant, only a small percentage of the Pu that has been found is of RFP origin, as explained below. The rest is from residual fallout from past global atmospheric weapons testing. An isotopic ratio (Pu-240/Pu-239) analysis was used by Krey to distinguish the RFP contribution from atmospheric fallout to one-tenth of fallout levels. The RFP contribution in the region east of Indiana Street is approximately 0.1 Ci total, according to Krey.

Another possible source of RFP Pu in the environment is from safety shots, i.e., non-fission detonations, at the Nevada Test Site (NTS). Plume deposition from these shots has been tracked as far east as Grand Junction, Colorado, where it contributes 0.6 mCi/km^2 to the Pu in soil (BE83, p23). Global fallout away from Nevada is of this order. The dispersion of NTS Pu has not been investigated east of Grand Junction.

Also of interest are the periodic aerial gamma surveys of the plant and surrounding land by helicopter using an array of sodium iodide crystal detectors (BO82; BO90). Figure 5 presents the 1989 survey contours for Am-241 (BO90). The 1981 aerial survey data show similar results (BO82). In 1989 the sensitivity of the aerial instrumentation was improved, making it possible to detect Am-241 beyond the cattle fence which marked the plant's original boundary (e.g., to the 250-mCi/km^2 contour shown in Figure 2). Also, the 1989 survey extended beyond the confines of the RFP buffer zone to obtain a broader picture of background radioactivity. As far as total radioactivity is concerned, which includes natural radioactive sources, the hottest localized spot was an old mine shaft near Leyden, several miles from RFP. The major contributor to this radioactivity was Bi-214 from radon gas (BO90, p11). To detect the above background radioactivity at RFP the survey has to be specific for Am-241.

The airborne surveys showed that Pu radioactivity has not migrated significantly beyond the original source area after the 1969 asphalt stabilization of the 903 drum storage area (BO90, p25). The 1989 study also included selected ground sampling points for Am-241 measurements (Figure 6). A portable gamma spectrometer was used for this purpose, to be followed by radio-chemical analysis for Pu from soil samples from the same location.

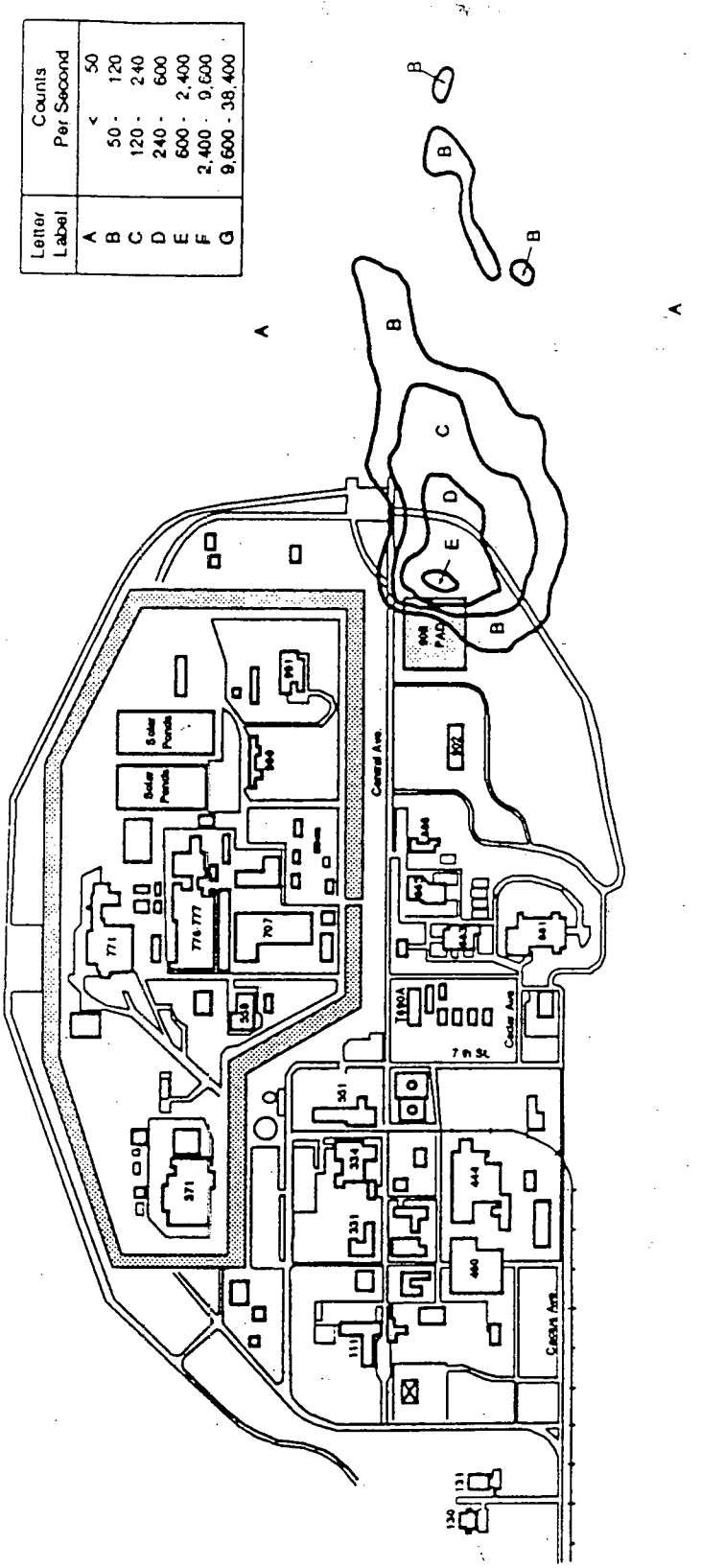

Figure 5. Aerial Gamma Survey - 1989

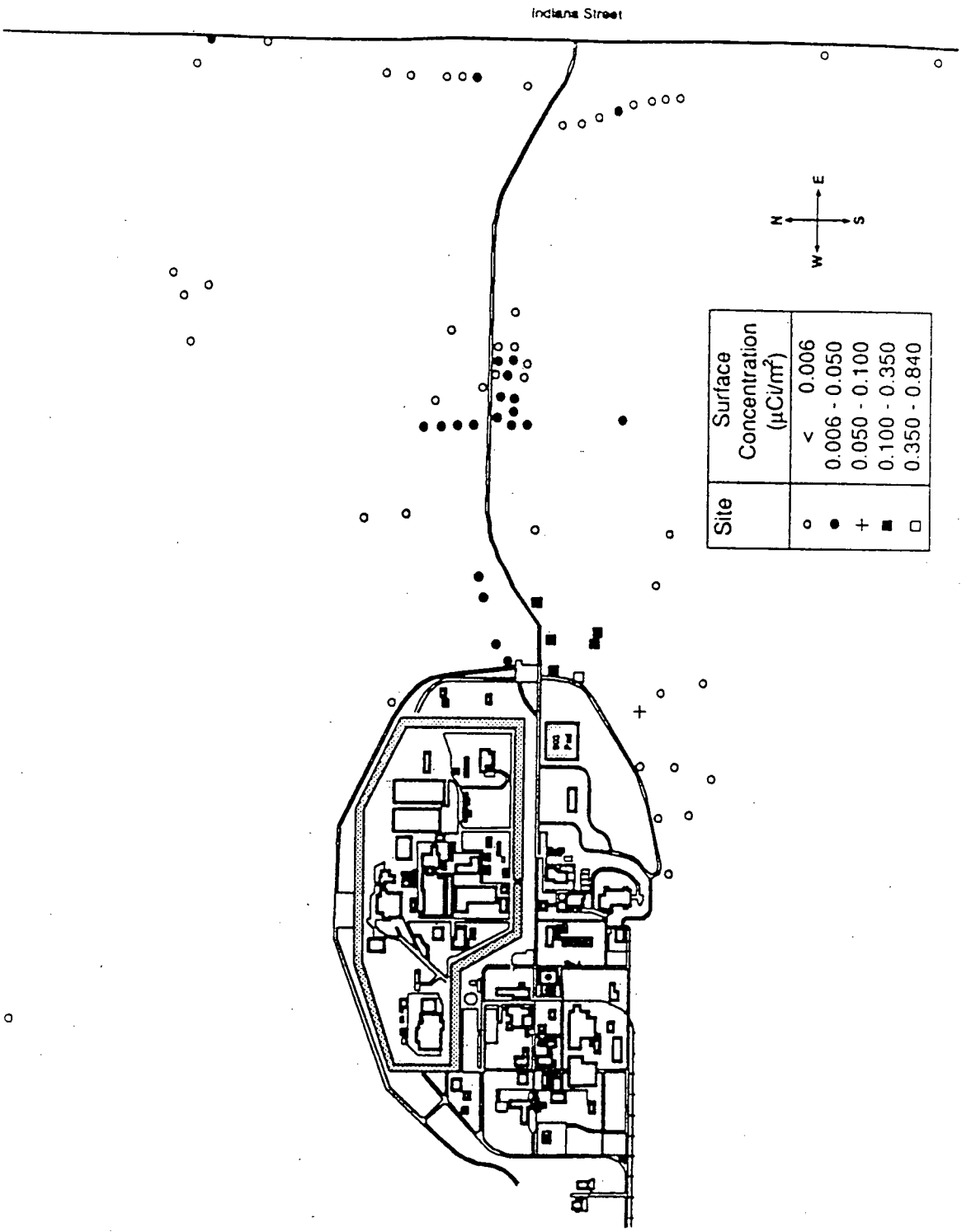

Figure 6. Gamma Ground Survey Sites for Am-241

PHYSICS OF SOIL RESUSPENSION

The potential for chronic release of airborne Pu particles from RFP is limited to soil resuspension from the 903 Field. Building releases from High Efficiency Particulate Air (HEPA) filters are small, i.e., a total of 5 μCi/yr in 1989 (RFENV-89, p23) vs. 200 μCi/yr from the 903 Field (see section on resuspension factors). We know from air monitoring that Pu particles do become airborne from soil, but the physics of the process need to be understood for dispersion modeling and remedial action purposes. Soil particles are traditionally thought to be resuspended by wind forces acting on bare soil surfaces, but studies upon which this view is based have been limited to plowed fields and desert areas. The 903 Field has only small bare soil areas between the clumps of bunch grass, but the original premise of the author and others was that the Pu particles originate from the bare soil between the clumps of grass.

Saltation

Initial resuspension studies were directed at the classical resuspension process of saltation (HA80a, p213). That is, the wind propels millimeter sized particles that protrude beyond what is called the boundary layer (the immobile or stagnant air layer approximately 1 mm in depth, adjacent to the land surface) in a series of small hops. On impact these large particles knock loose smaller particles, in a manner similar to sand blasting. The smaller particles then become entrained into the main air streams by turbulence to heights over 6 m at a distance of less than 30 m (HA80a, p222).

It remained for RFP to demonstrate if saltation could occur from small areas devoid of vegetation, because this soil surface condition has received little attention from soil scientists. Direct visual observations initially indicated that even during wind storms reaching over 100 mph, no visible quantities of dust were released (e.g., puffs of dust from bare areas). Operation of a modified Bagnold Catcher for several week-long runs, including operation during wind storms, provided no weighable dust fractions. The Bagnold Catcher (GI74) is the classical device for measuring wind erosion of soil. Nevertheless, more sensitive techniques were developed to verify if saltation processes occur on a small scale.

One technique developed by RFP was the application of a ribbon-like laser beam grazing the soil surface, to detect impacting large particles and bursts of numerous small particles

(RF3197, p8). This was done at night using time exposure photography. No particles were observed until winds exceeded 35 mph, but even then resuspension was tenuous and no clear evidence for saltation was found by this approach (RF3325, p3).

The second methodology, shown in Figure 7, involved the placement of an acoustic particle detector underground, facing a 2.5-cm opening in a soil surface area devoid of vegetation (RF3115, p11). There was no net airflow into the opening, but the objective was to detect particles over 50 μm aerodynamic equivalent diameter (AED) that were resuspended by the wind and then fell back to the ground. As the particles fell back, some dropped into the intake of the acoustic particle counter. This system could operate continuously and unattended for several days. Again, no convincing case could be made for saltation, even in high winds (RF3115, p13; RF3197, p7). Evidently, the soil is too crusty for wind erosion (HA80a, p224), except for a few small areas (RF3115, p11). Also, many of the smaller, bare areas are too deep in the grass canopy to experience the full force of the wind. Only deliberate disturbance of the ground with a stick was observed to release short bursts of particles.

The above results may seem to contradict a study by Sehmel, who developed a Pu resuspension model for the 903 Field based on the saltation process (SE72). However, this model was based on data collected by RFP from July 1970 through January 1971. In March 1970 the 903 Field was disturbed by a major ditch construction project near the west side of the perimeter fence. It took nine months for the effects of this operation to disappear, i.e., for the loose surface soil to become crusty again and for introduced grasses to grow.

Next, resuspension studies were carried out under controlled conditions using the small wind tunnel shown in Figure 8 (RF3197, p5). The objective was to observe resuspension from bare ground as well as from grassy areas. Testing of bare spots showed very little release until extreme wind velocities (e.g., equivalent to 150 mph at 10 m or about 30 mph near ground levels) were applied or the soil had previously been disturbed. But even the latter, "fresh" surface was quickly exhausted of particles (RF3689, p36). This wind tunnel, at high flow, proved to be a useful approach to soil surface sampling for Pu particles and was extensively used for this purpose (RF3689, p23).

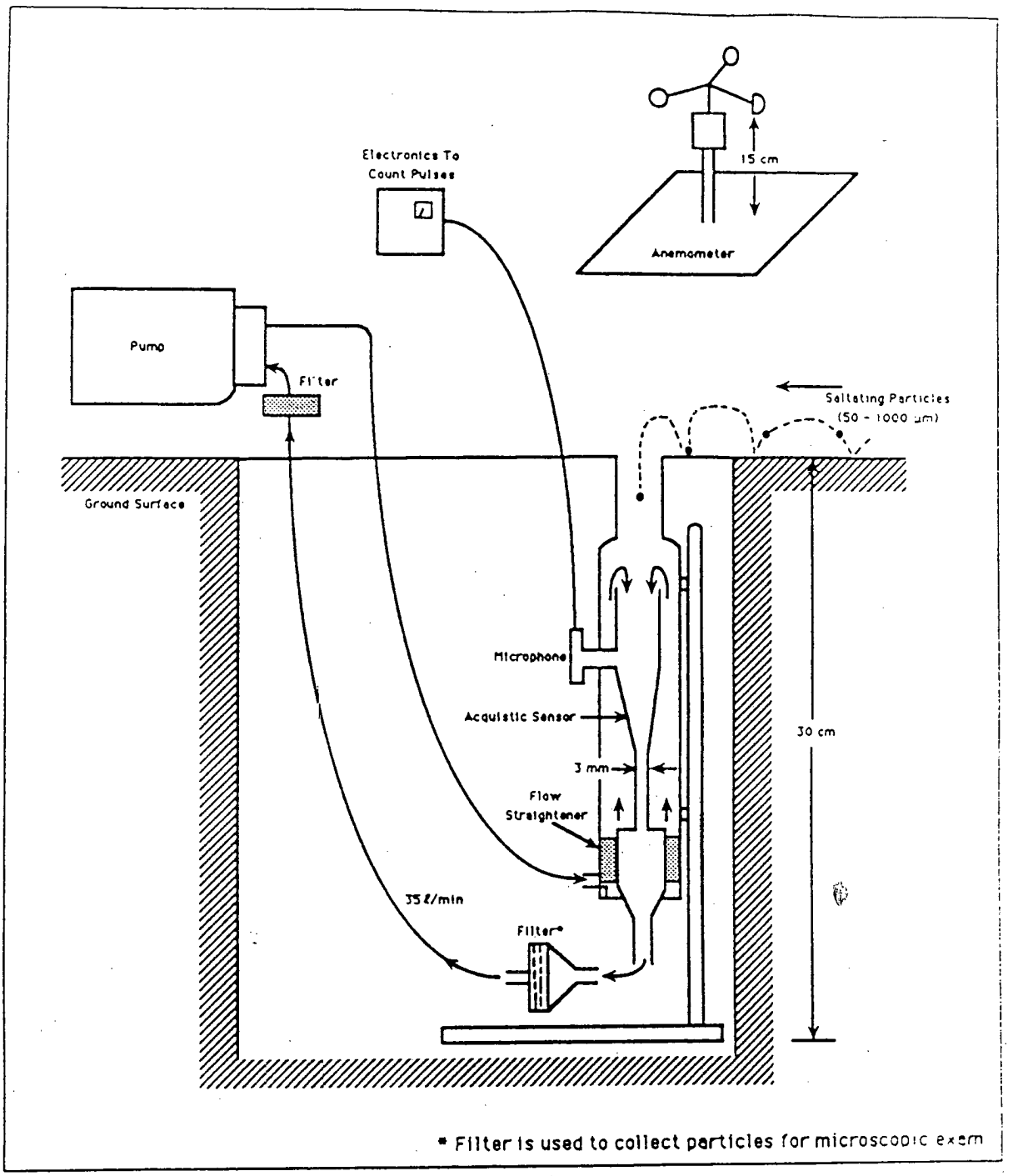

Figure 7. Acoustic Particle Counter for Saltating Particles

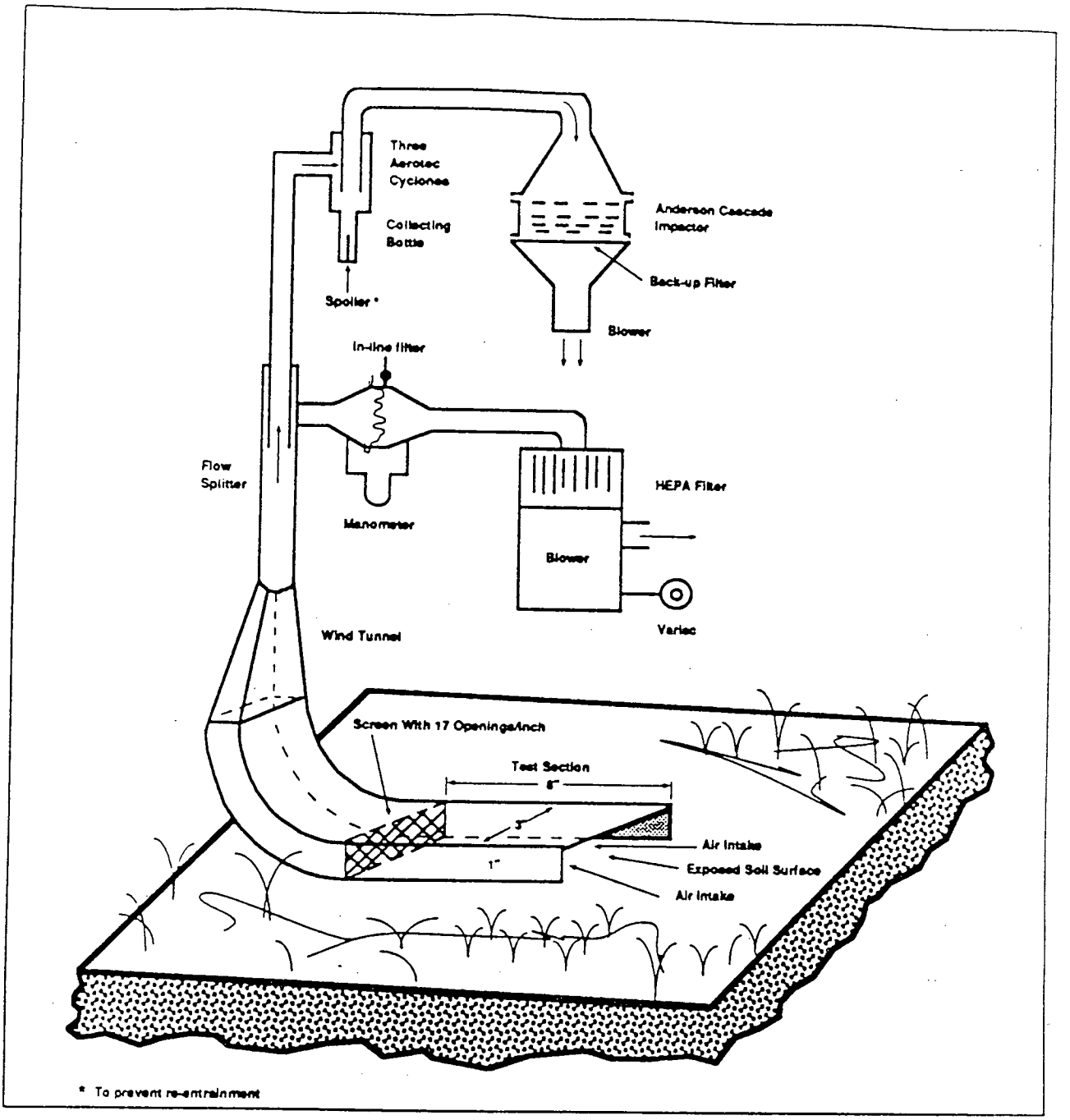

Figure 8. Portable Wind Tunnel for Resuspendable Dust

The wind tunnel was also operated on patches of grass, although it was not designed for this purpose. The height of the wind tunnel test section was less than the height of the grass. For proper testing of grass covered areas a considerably larger wind tunnel is required, such as the Gillette device (GI78). Nevertheless, even at low velocities (e.g., wind speeds equivalent to 20 mph at 10 m) the small wind tunnel detected small but significant amounts of resuspended Pu-carrying particles. This was considered important, since most of the ground in the 903 Field is grass covered. Much of the resuspended material was over 10 μm AED and was organic (i.e., grass litter) as shown by ashing the samples. The organic content was about 40 percent on the average (RF4036, p23).

Resuspension from Grass Blades

As a result of the aforementioned wind tunnel studies, attention was now focused on the details of resuspension from grass covered areas. It was not certain whether Pu resides on the grass blades and then becomes resuspended or if it originates from the grass litter on the soil surface and, as the grass decays, is then resuspended as part of decomposed grass particulates. Research was conducted to determine if both processes could be taking place.

First, it was verified quantitatively that Pu does reside on grass and grass litter (RF3914, p6). This was done by clipping the grass at successively lower levels and measuring each level for Pu distribution in relation to ground height. The Pu concentration in the underlying grass litter was also measured. Pu radioactivity was distributed fairly uniformly in relation to height for a total of 1.1×10^4 pCi for grass grown on a square meter of soil with a radioactivity of 2200 pCi Pu-239/gm of soil. The grass litter held 510 pCi Pu-239/gm of litter. Therefore, live grass must be considered a major source of Pu particles for resuspension in addition to the underlying grass litter. It should be noted that the litter is not readily accessible for resuspension because it is shielded from wind by the live grass.

The question of how the Pu becomes attached to the grass is of interest. Plant uptake of Pu is not a factor, because we are dealing with insoluble Pu particles (AR82, p33). This leaves wind driven soil particles from bare soil areas and rain splash as the source of Pu. The latter process is well documented for transferring Pu to vegetation to heights up to 30 cm (DR84, p183). Finally, the growth process of the grass as it rises through the soil surface was considered as a means of transferring Pu to the blades, but the grass blades

start from the stem of the plant after it has risen out of the ground. Therefore, no direct transfer of soil particles to the blades takes place.

Information was now required on the capacity of grass blades to hold soil particles and on potential Pu resuspension mechanisms from the grass. Therefore, the surface of grass blades was studied with a scanning electron microscope. Most grasses at RFP have blades whose surface is covered with fine fibers that act like a filter matrix which intercepts considerable amounts of dust (RF4036, p15). C. Gutfinger reports that fibrous elements extending from a surface into the viscous boundary layer enhance deposition by a factor of 10 to 1000 (GU85, p3). The microscopy showed that the blades were heavily loaded with soil particles. Conversely, dust particles should be released when the grass fibers decay and fall off and when the blades flex due to wind. Such behavior was verified with the wind tunnel tests described below.

In a small laboratory wind tunnel (RF4036, p23) samples of grass were placed in the test section and exposed to air velocities that would be found at grass level due to winds of 5 to 20 mph at a height of 10 m above ground. From a 5-cm blade of grass about 200 particles were released in the 0.2 to 12-μm range, as verified with an optical particle counter and membrane filter samples. Most pertinent were tests where the blades were mechanically flexed, which simulated wind motion. Here, the release from the blades of particles greater than (>)10 μm was dominant, with a median diameter of 20 μm and a maximum of 40 μm.

To verify the above results in the field, a simple test with the soil resuspension wind tunnel was made in summer with the ground soaked with water but the grass dry (RF3914, p8). The object of this test was to demonstrate how much Pu is resuspended from grass blades alone. The blades are much more exposed to the wind than the ground but may hold dust more tenaciously. The resuspension rate was about one-sixtieth of that for a similar dry area at a wind speed equivalent to 80 mph at 10 m. At 20 mph it was one-fortieth less than at 80 mph. But these resuspension rates could still account for most of the radioactivity observed by the air samplers, since 95 percent of the field is covered with grass. These data have to be interpreted with some caution, because as pointed out above, the wind tunnel was not of an optimal design for studying resuspension from grass.

This test confirmed that the release of radioactive particles from grass blades alone is important, if not dominant. Additional radioactivity exists on dead grass litter on the

ground between the standing grass, but this material is not readily available for resuspension because it is protected from the wind by the stands of grass.

Rain Splash

To determine the amount of Pu resuspension when the soil is completely saturated during long periods of rainfall, such as that encountered in spring (RF3914, p9) a series of tests were conducted. For this limited test series the airborne Pu concentration during rainfall did not differ significantly from that during dry periods. Rain splash was therefore studied as a means of releasing Pu particles into the air. First, a laboratory wind tunnel was set up to simulate single raindrops splashing on soil under controlled conditions. Provision was made to count resuspended soil particles by concentration and size with an optical particle counter. This experiment showed that soil particles do become aerosolized by rain splash, if a thin water layer exists on the soil surface (RF4036, p30).

Evidently, these airborne soil particles are the residuals that remain upon the evaporation of the hundreds of small satellite droplets that form along with big splash drops (GR73, p57). The satellite droplets are small enough to be carried by air currents.

This resuspension process was also field tested. A small plastic tent was built over a patch of Pu-contaminated bare soil at the 903 Field (Figure 9). The tent was necessary to prevent airborne Pu particles from drifting into the test area from the surrounding area. Nuclear track foils were placed on the resuspended residue particles collected from the splashes to verify the presence of Pu particles. The tests showed that soil particles containing Pu did become airborne due to drop impact (RF4036, p30). A thousand 5-mm rain drops resuspended 5 pCi into the air from soil with a surface radioactivity concentration of 2500 pCi/g. About 500 million raindrops may fall on an area of one square meter annually. To complete this analysis, the washout of resuspended soil particles by rain drops should be accounted for in a real situation (GR73, p121). The washout effect was not present in the aforementioned single drop experiment. The washout effect decreases the airborne Pu concentration as falling raindrops sweep out dust particles in the air.

Grass Fires

Another potential source of resuspended particles is the ash from grass fires. So far no fires have taken place in the 903 Field, but RFP has conducted tests to simulate such an

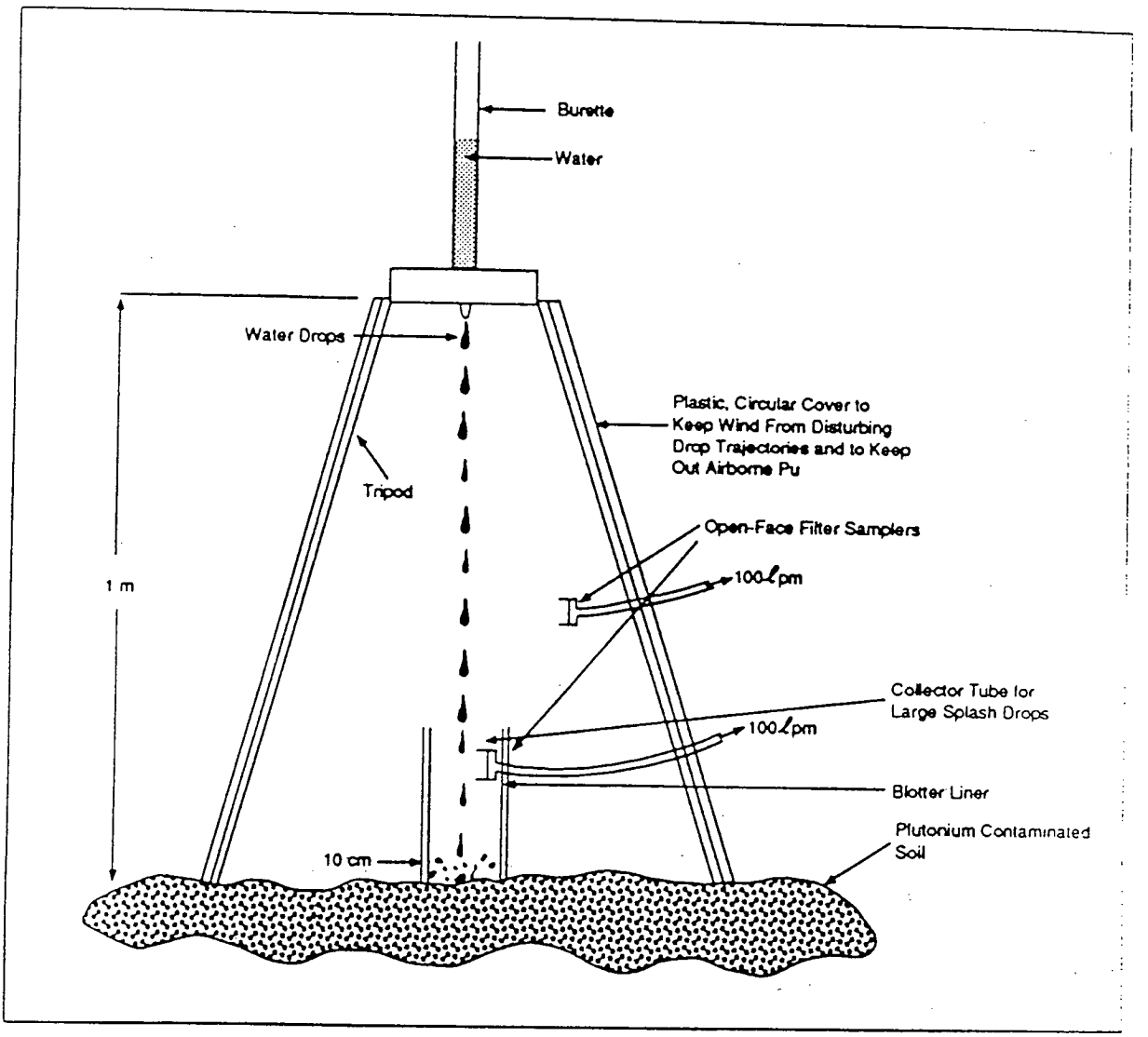

Figure 9. Simulation of the Resuspension of Plutonium-contaminated Soil Particles by Rain Splash

occurrence. Fire was set in a wind tunnel to 180 gm of grass collected from an area of soil 1 m^2 in size. The grass had a radioactivity concentration of 8.1 pCi Pu-239/g of air-dried grass. Smoke from this test fire had a total radioactivity of 34 pCi of Pu-239 or 17 pCi/g (LA86, p91). However, placed in perspective, consider that the annual limit on intake for a member of the public for Pu-239 is 170 pCi (DO90). If the whole field (0.02 km^2) were to burn, a person remaining in the plume would inhale a small fraction of this limit.

Mechanical Disturbances

Mechanical, or unnatural, disturbances were also studied as a potentially important resuspension mechanism. This includes such activities as mowing, well drilling, construction, digging, or soil removal. Mowing was considered of major interest since it takes place every year and covers the whole area. Mowing involves disturbance of both grass and soil. While research sampling took place in the 903 Field east of the plant security fence, the grass was cut during dry conditions. This was expected to maximize resuspension. At times the mowing tractor would pass right next to an air sampler. A statistically significant increase by a factor of 5 in the total Pu concentration was discerned during such a period in June 1981 (RF3464, p4). But no change was found during a similar period in 1983 at the same location (LA86, p90). Again, high variability in Pu concentrations make trends difficult to establish unless many samples are taken. In June and July of 1987, wells were drilled in the 903 Field and the nearby surveillance air samplers showed an increase by a factor of about 3 in Pu radioactivity, but such increases are often seen during the dry summer months regardless of soil disturbances. Mechanical disturbances are short-term events.

Consideration was also given to resuspension of dust containing Pu from two unpaved roads intersecting the 903 Field along the security fence. It is evident from the color and quantity of the dust collected by samplers located along the roads that much of it is resuspended by traffic. A 1973 study (MI73) showed that road dust radioactivity averaged 68 pCi/gm and remedial action was initiated (e.g., oiling, grading, etc). In 1980 another road dust evaluation was carried out. As a first step the Pu radioactivity of the road surface for one of the roads was determined by conventional soil sampling methods (RF3689, p18). The Pu radioactivity of this road surface was surprisingly low, 4.6 pCi/g of Pu-239, when compared to adjacent soils of 790 pCi/g of Pu-239 that were monitored a distance of one foot from the road. However, since 1973 the road was often graded and ballast added. It had been expected that the adjacent soil would provide a source of Pu for easy resuspension by traffic on the dirt road. However, the adjacent soil was not disturbed by traffic on the road.

Also in the 1980 evaluation a truck was driven along this road to complete the comparison with the 1973 test, and to sample a larger area than that covered by a few road soil samples. The dust generated behind a rear wheel was sampled with a high-volume air sampler (hivol) similar to that used for the dispersion studies described later. The device gives a

<3-μm and >3-μm cut. The road dust was very low in radioactivity, measuring 6.0 pCi/g of Pu-239 compared to 1000 and 2000 pCi/g of Pu-239 for two adjacent soil areas. It was concluded that the roads are no longer a significant problem, especially because of the low volume of traffic. Of considerable interest was the incidental new information that no measurable amounts of respirable (<3-μm AED) particles are generated (RF3287, p7). This was also observed during a recent dam construction project at RFP. Heavy earth moving machinery created no additional respirable dust (RF3115, p6).

Such observations indicate that considerable application of force is necessary to create <3-μm AED particles. It has been noticed that the particles <3-μm AED were mostly black combustion particles generated by vaporization-condensation (e.g., combustion) by vehicles, furnaces and other industrial activity. This is in line with the wind tunnel results, that soil resuspended from the field is very low in respirable particles, those less than 3 μm in size (RF3689, p35) and many of these particles found at RFP are a result of Denver pollution (RF3990, p31).

DISPERSION OF Pu PARTICLES FROM RFP

Combining the above processes into a coherent, predictive Pu transport model is obviously beset with problems, especially with the resuspension from the 903 Field being relatively low and of varying nature (wind, rain splash and release from grass). Procedures from previous studies can be used to derive conventional resuspension parameters which are commonly used to provide a rough estimate of the emission of soil particles containing contaminants (HA80a, p210). Such parameters are given in the section titled: "Resuspension Factors for Pu Release from the 903 Field" in this report. However, site-specific experiments were necessary for realistic estimates of Pu dispersion from RFP which would directly measure the emission and transport of Pu particles. These experiments included measurements of the vertical distribution of Pu particles in the air that passes over the 903 Field.

Two distinct steps were involved in these experiments. First, an attempt was made to measure the Pu particle flux from the 903 Field at the source. A number of research air samplers were deployed at selected points in the field to determine the total resuspension of Pu. Second, a vertical array of samplers was installed, at some distance from the 903 Field, to measure the Pu particle concentration in the air that passed over the field.

Determination of Pu Flux Characteristics for Source Area

For the first step, four research hivols (~1 m^3/min) were installed toward the perimeter areas of the 903 Field and an ultrahigh-volume air sampler (ultravol - ~7m^3/min) was installed near the center of the field to determine how much Pu is being released to the environment. The ultravol (Figure 10), operating at 7.4 m^3/min. and providing a <10-μm and >10-μm fraction, was changed weekly or more often to provide high resolution Pu concentration data (RF3197, p6). This was used for special events such as wind storms, periods of snow or rain and fallout from atmospheric nuclear weapons tests (RF3464, p5). The research hivol samplers provided <3-μm AED and >3-μm AED fractions. These corresponded to a respirable and an inhalable-plus coarse particle size cut, respectively. The >3-μm AED fraction was collected by combining the particles collected by a cyclone pre-separator with a nominal 5-μm cut, followed by two impactor stages to provide a sharp 3-μm cut. The cyclone sampler inlet was designed to turn with the wind so that the intake always pointed into the wind. The efficiency of the cyclone was evaluated and one

observation was that the inlet efficiency was not sensitive to wind speed, that is, the particle concentration and size distribution was unaffected by wind speed (RF3464, p34).

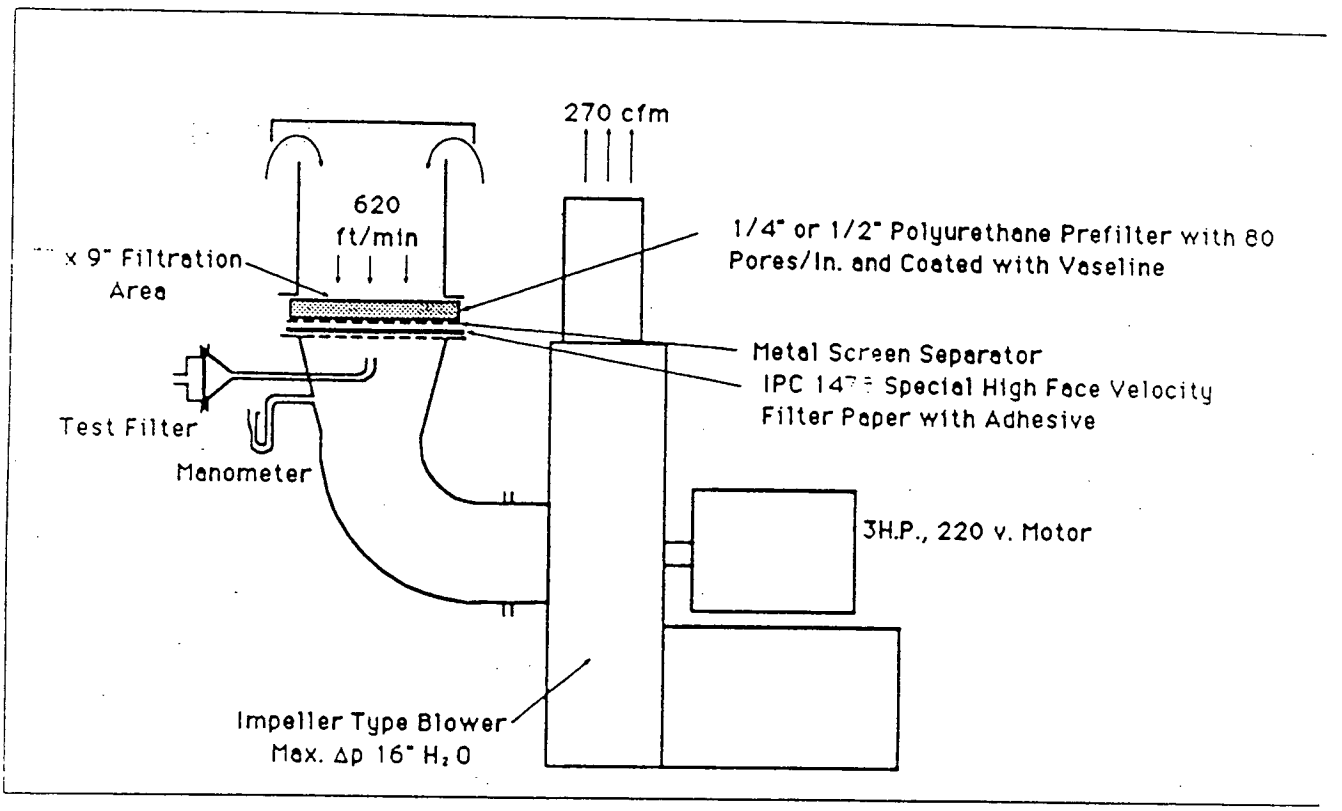

Figure 10. Ultrahigh-volume Air Sampler

The results of approximately two years of sampling (RF3464, p4; RF3650, p1) showed that monthly Pu concentrations in air that passed over the 903 Field varied by a factor of 10 to 100 at a given sampler location over a two year period. No correlation between wind speed and Pu concentration was found. Nor was there any correlation between the Pu concentrations found at the four sampler locations when plotted against time*. This observation even held for another experiment with three samplers at the same location (RF4036, p17, 23). By contrast, the corresponding dust concentrations for these tests varied by a factor of two during the same period and the concentration values at each sampling station showed identical trends with time.

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* The same was true for the three RFP surveillance samplers spaced across the pad field along the security fence, i.e., the concentration data between the three samplers did not correlate in time (RF3914, p4). That is, if one sampler had a high concentration the others showed no corresponding increase, etc. The data examined were for a 9-year period.

Naturally, it is desirable know why the Pu concentrations in air at the source area varied so randomly. Especially in view of the fact that the concentration of another radioactive trace material, Be-7, correlated very well between all the samplers versus time (RF3287, p31). Be-7 is of stratospheric origin and consists of near atomic-size particles, which become attached to many dust particles in the troposphere. It is important to note that Be-7 is determined at the same time as the Am-241 values by gamma spectroscopy. The Am-241 gamma spectroscopy values fluctuated widely but correlated with the Pu values determined by alpha spectroscopy, confirming the accuracy and precision of the Pu analytical procedures (RF3650, p5-6). The next step was to examine data on Pu particle size on the presumption that the Pu particles may be relatively large and therefore few in number.

Unfortunately, data on the size of airborne Pu particles at the 903 Field are lacking. Alpha track analysis of an 8" x 10" filter proved to be quite tedious. Only a few tracks per square centimeter were present and most of these were single tracks, indicative of uranium. It was estimated from the multiple tracks that the Pu particles ranged from 0.08 to 0.3 μm (RF3115, p17), but the counting statistics were poor at a × 100 microscopic magnification (i.e., alpha tracks were seldom seen). Wind tunnel resuspension of surface soil particles in the 903 Field (i.e., Pu sources area) revealed that the most common size was 0.06 to 1 μm (WA82, p23). This work was much more definitive because many alpha tracks were present in a microscope counting field.

Finally, Pu particle size data from the soil itself are of interest. Whicker (WH79) reported that most particles were 1 to 2 μm in size. Langer (RF3990, p43) reported Pu particles up to 10 μm in size. An interesting scanning electon microscopy study (ME90, p48-55) by EG&G Idaho of Pu-contaminated soil from Rocky Flats led to the identification of soil particles as large as 30 μm that contained Pu. This confirmed the idea that Pu is carried by host particles. This work also indicated that these large particles are fragile agglomerates.

From the above data it is concluded that the airborne Pu particles sampled were a few discrete, relatively large particles in a huge volume of air. This is very unlike sampling a continuum of a trace gas or atomic clusters of Be-7 attached to many dust particles. To illustrate this point, for a relatively high Pu concentration of 1.4 fCi/m^3 in the 903 Field, 125 Pu particles 1 μm in size would account for the activity found in 40,000 cubic meters of air sampled during a typical run; or, a single 5-μm particle could account for all the activity. Such poor sampling statistics make it impossible to establish short term

concentration trends. That is, at best one can statistically compare only yearly or longer averages from each 903 Field sampling station for meaningful trends. For the community samplers, miles away from the 903 Field, it is impossible to establish Pu trends that relate to RFP activities.

The data cited also showed that most of the Pu activity is on particles >3 μm. To better define the Pu activity vs. particle size, large dust samples (gram-sized, as found during dust storms) were subjected to wet sieving of the >3-μm AED particles into 44 and 74 μm sieve cuts. Freon was used for the suspension medium to prevent de-agglomeration (HA80a, p219). This sieving showed that the Pu distribution is roughly proportional to dust particle mass (RF4036, p22). More accurately, the specific radioactivity of the Pu in the samples was three times higher for the >3 μm fraction than for the respirable fraction. But the specific radioactivity for the respirable fraction was small and not as accurately determined.

During normal wind conditions another test series gave the following results. The concentration of the respirable Pu fraction, 0.02 fCi/m^3 of Pu-239, was nearly at the fallout level of 0.018 fCi/m^3 of Pu-239 for June 1980 to June 1981 (RF3650, p6). The >3-μm AED particle radioactivity was 0.71 fCi/m^3 of Pu-239. There is little emission of <3-μm AED particles from the 903 Field (RF3464, p4). The >3-μm AED fraction carried 97 percent of the radioactivity for the above period.

As an aside, in the spring, large amounts of pine pollen were blown from the foothills over the plant and were collected by the air samplers. Pollen is designed by nature to float long distances due to small air sacs. Scanning electron microscope photos of the coarse particle dust fractions showed the presence of pollen (RF3990, p28) which causes a yellow/green discoloration of dust collected in early summer. No unusual increase in Pu activity was seen during these periods, as suggested by Nichols (NI74).

Dispersion of Pu by Air Passing Over the 903 Field

The above studies were followed by an air sampling program using a scaffold 10 m in height and located 100 m from the eastern edge of the 903 Field (RF3914, p16). The objective was to follow the transport of Pu from the 903 Field. The scaffold had hivol samplers at a height of 1, 3 and 10 m to sample the air that passed over the 903 Field for Pu particles. The three hivol samplers had EPA-researched size selective inlets (SSI) with a

cut of 15-μm AED particle size, followed by 3 to 15-μm AED and <3-μm AED cuts. At the time the experiment was started the EPA defined the inhalable particle cut-point at 15 μm AED. This was later changed to 10 μm. The SSI was evaluated for wind speed (1-10 mph) response (intake sampling bias) by Wedding (WE82) and McFarland (MC84) in wind tunnels and by RFP researchers during 50-100 mph winds in the field (RF3914, p4). Performance was satisfactory at low speeds, but at the high wind speeds some particles were apparently blown through the circular SSI inlet and out the opposite side without being sampled. The particle flux data from this scaffold represent the sum of all resuspension processes active in the 903 Field during each two month sample period. The long sample period is necessary to accumulate sufficient Pu for analysis. These data provide basic information to estimate possible population exposure and translocation of the Pu particles from the source area.

This research program extended from November 1982 thru August 1985, collecting bimonthly samples. This two month collection period was necessary to collect sufficient Pu in each size fraction for detection. The dust concentration data showed well defined trends with sampling height (RF4036, p21). However, the respirable dust particle concentration (8.0 $\mu g/m^3$) did not change with height, as expected for particles that are slowly sedimented. The concentration for the inhalable and coarse dust particles, ranging from 10 and 25 $\mu g/m^3$ respectively, dropped off with height due to sedimentation.

The Pu concentrations (RF4036, p21) for the <3-μm or, what are termed respirable particles, was 0.0088 fCi/m^3 of Pu-239 and for inhalable (3-15 μm) particles was 0.025 fCi/m^3 of Pu-239. These concentrations did not correlate with height, being only 3 and 10 times greater than background concentration respectively. One must keep in mind that the Pu mass for these samples represents about 1/10th part per billion of the total sample mass. Statistically the data have to be erratic at such extremely low concentrations. For a Pu concentration of 0.010 fCi/m^3, typical of the respirable Pu particle concentration at the scaffold, it would require the collection of just <u>one</u> 1-μm Pu particle per month by a hivol operating at 1.1 m^3/min.

The concentration of 0.067 fCi/m^3 of Pu-239 in the coarse (>15-μm) particle fraction was almost a magnitude higher than that in the respirable fraction (<3 μm). The coarse fraction exhibits a significant decrease in radioactivity with height by a factor of 3 from a height of 1 to 10 m.

No correlation was found with wind speed or direction for the Pu or dust concentration. This can be expected for the poor time resolution given by two month sample periods necessary to collect enough Pu for analysis (e.g., for the <3-μm particles).

It was obviously of interest to see how the Pu concentration changes beyond the 10 m scaffold. As a result, the ultravol sampler was operated in June 1981 at the cattle fence (Figure 2) 0.5 km due east of the scaffold. The Pu concentration in the inhalable (<10-μm) and coarse (>10-μm) ranges dropped off by a factor of 20, approaching background levels (UN81). Therefore, it did not seem worth while to continue this operation at such low levels. Evidently, most of the large Pu/soil particles that carry the bulk of the Pu radioactivity had settled out before reaching the cattle fence in the RFP buffer zone, far from any populated areas. This observation is directly supported by work of J. Hayden (HA75), who measured the size of individual Pu particles found on the soil surface from the 903 Field to Indiana Street, located 1.5 miles to the east (Figure 2). Beyond the cattle fence he considered RFP stack effluent to be the primary source of Pu particles because of the small size of these particles. The 1957 fire may have produced some small particles that settled out beyond the plant boundary. The total release was estimated at 26,000 μCi (EI80, p3-53).

Comparison of RFP Data with Previous Resuspension Studies

It is of interest to compare the above results to G. Sehmel's July 1973 Pu resuspension experiments at RFP (HA80c, p241). Although Sehmel's was a more elaborate Pu flux study than the study cited above, it only lasted for one month. Sehmel used three sampling scaffolds, one at the fence near the 903 Pad, one at the same location as the RFP 10 m scaffold and one near the cattle fence.

It is difficult to directly compare Sehmel's data to this study, because this study covered 34 months to determine statistically significant trends in the Pu concentration at three levels at one location. Sehmel's study probed the Pu particle plume at three locations with nearly 40 samplers set for specific wind speed ranges as well as continuous operation. However, to reiterate, Sehmel's research work was only of a month's duration.

There is also a problem comparing the particle fraction data. To achieve well-defined particle-size fractions, RFP took considerable precautions to coat the collection surfaces with adhesive. The object was to stop particles from bouncing through the cyclone and

cascade impactor stages onto the back-up filter (RF2866, p14; RF3115, p4). The SSI hivol inlet was also adhesive coated, long before this was an EPA requirement. Sehmel did not use adhesive on his collection surfaces. He showed that 60 to 99 percent of the Pu was in the respirable range and supposedly of RFP origin (HA80c, p262). We found that respirable Pu was mostly of fallout origin and it only represented 2 and 9 percent of the total Pu radioactivity, based on measurements at the scaffold and 903 Field respectively. Therefore, the Pu size trends are not comparable.

The drop off in Pu concentration as distance increased from the 903 Field security fence to the second scaffold varied among samplers by a factor of 10 to 1000 in Sehmel's tests (HA80c, p251). Comparable simultaneous data from our study were not available, due to access to only five hivol samplers. But taking data over the period 1980 to 1985, as RFP experiments moved eastward, the average Pu radioactivity at 1 m changed from 1.9 to 0.48, then to 0.13, and finally to 0.050 fCi/m^3 measured respectively in the 903 Field, just east of the field, the scaffold, and the cattle fence. This trend represents a 40-fold reduction over a distance of 1.5 km.

Sehmel did not report a definitive relationship between wind speed and Pu radioactivity (HA80c, p244). This is similar to RFP research experience in this area.

Isotopic Ratio Determination as an Indication of Long Distance Dispersion of RFP Pu

As a final test of whether any RFP Pu particles reach the general population, the mass isotopic ratio of Pu-240/Pu-239 was determined for a series of airborne particulate samples (RF4036, p22). RFP Pu production metal has a Pu-240/Pu-239 mass ratio of 0.051, while fallout has a ratio of 0.163. Airborne dust samples collected at the scaffold showed a ratio of 0.063 and nearby soil had a ratio of 0.054. This small difference was significant, indicating that the airborne dust carried some fallout Pu, as to be expected. It is now needed to obtain the isotopic ratios for air samples taken in various parts of the Denver region to identify the RFP contribution, if any, from 903 Field resuspension or production facility emissions.

For the latter program it is also necessary to take soil samples at the air sampler sites, since most background Pu (fallout Pu) now originates from resuspension of nearby soil particles (RF4036, p29). Stratospheric influx of Pu is very low at present. Therefore, the isotopic ratio of the soil should be known at the air sample sites to adjust for any RFP Pu, if any.

already in the soil, in addition to the fallout Pu from past nuclear weapons tests. Nearly 20 years ago isotopic ratios were determined by Krey (KR76, p213) for a limited number of soil samples in the greater Denver region to identify RFP Pu. This would also be a chance to determine if any changes occurred in these ratios. Krey's data show that 1 to 2 percent of RFP Pu deposited in the environment due to releases from the 903 Pad, plant stacks, and the 1957 and 1969 fires, extends beyond Indiana Street.

Resuspension Factors for Pu Release from the 903 Field

The resuspension factor (R_f) estimates the airborne contaminant concentration directly above a contaminated area and provides a means to estimate exposure or dose. R_f equals the airborne Pu concentration measured directly above a given area divided by the soil surface Pu concentration at that location. The necessary Pu data to calculate resuspension factors for the 903 Field are available. The soil surface Pu concentration is derived from the soil density and soil radioactivity per unit mass.

Another resuspension parameter is the resuspension rate (R_r), which allows off-site dose calculations. R_r is the fraction of the total radioactivity in the soil released per second. This provides a source term for meteorological calculations to determine downwind population exposure. R_f only provides dose or exposure for a person present on the contaminated area, which is somewhat academic for real life situations, because plant personnel only spend limited time on or near the 903 Field. The RFP Pu flux data make it possible to estimate R_r, but estimates of the Pu particle plume profile have to be made.

Before proceeding to estimate R_f and R_r, the limitations for applying these factors should be understood. Resuspension factors/rates ignore the physical parameters affecting resuspension, such as wind speed, vegetative coverage, soil moisture, precipitation and contaminant/host particle size. Also, a good knowledge of the Pu surface distribution is assumed, as well as airborne concentration over the whole area in question. As Sehmel (HA80c, p269) correctly points out, realistic prediction of the relationship between surface concentration and airborne concentration is fraught with uncertainties. Such data are very site specific and depend on how the contaminant found its way into the soil/vegetation and how long the contaminant has "weathered" into the soil. For example, resuspension for the first few weeks, after a tracer was sprayed onto cut grass, was orders of magnitude higher (RE79, p27) than the RFP data given below. The preference is to use actual Pu concentration data and then draw conclusions.

Sehmel (SE72) probably made the best estimates of maximum resuspension factors at RFP for a special situation in 1969, when Pu releases were high with no vegetation on the 903 Field during the remediation project that involved earth moving machinery. Samples were taken for time periods as short as six hours in the source area. The R_f values ranged from 10^{-9} to 10^{-5} m^{-1}. However, these factors are no longer applicable, unless similar areas of fresh soil are exposed.

An R_f range of 10^{-13} to 10^{-10} m^{-1} was calculated by us, limited to areas near the 903 Field sampler (RF4036, p44). The variability in soil Pu radioactivity (see Figures 3 and 4) and ground cover raises serious questions about generalizing from these values to the entire 903 Field. The same applies to the calculations for R_r, which was estimated at 2×10^{-12} sec^{-1} for the entire 903 Field area. This calculation required an estimate of the average air flow over the field and the resulting fetch for resuspended particles. This parameter was used to estimate the total emission of Pu from the field to be ~200 μCi per year.

The question of Pu transport to populated areas is better answered by downwind Pu concentration data provided earlier in this report. These long term measurements show that the Pu resuspended from the 903 Field does not contribute appreciably to off-site dose. The 903 Field influence beyond about 1.5 km could not be discerned. To further confirm this observation, future studies are suggested, involving additional air sampling along Indiana Street with improved air samplers that do a better job of efficiently collecting larger airborne particles (RF3650, p20). The Pu samples should be analyzed for the Pu-240/Pu-239 ratio as well as samples of nearby soil to identify their sources, such as fallout or Pu generated at RFP.

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APPENDIX D

STACK DATA FOR POINT SOURCES

Stack Data for Point Sources

Building/ Location	Height[a] (m)	Diameter (m)	Width (m)	Length (m)	Exit Velocity (m/s)	Stack Type	Vent No.
123-001 through 004	6 .00	0 .61	--	--	f	Grouped	f
371-SSS	16 .00	--	1 .54	5 .76	3 .44	Penthouse	f
371-NO1/NO2[b]	16 .00	--	1 .54	5 .76	8 .72	Penthouse	f
374-MAI	23 .77	--	1 .83	1 .37	14 .25	Penthouse	f
374-SPD	9 .14	0 .42	--	--	21 .35	90°	3
444-D05	3 .56	--	0 .76	0 .61	10 .78	90°	122
444-MAI	5 .90	--	2 .74	2 .44	6 .41	90°	200
447-MAI	4 .00	--	1 .83	1 .52	8 .64	90°	201
559-561	7 .00	--	1 .22	1 .22	14 .55	Gooseneck	f
707-101	11 .33	0 .36	--	--	3 .48	Gooseneck	f
707-102[c]	11 .33	--	0 .91	0 .91	2 .91	Gooseneck	f
707-105	11 .33	--	0 .91	0 .91	3 .15	Gooseneck	f
707-106	11 .33	--	0 .56	0 .56	2 .57	Gooseneck	f
707-107	11 .33	--	0 .91	0 .91	6 .63	Gooseneck	f
707-108	11 .33	--	0 .76	0 .76	6 .26	Gooseneck	f
707-R21A	13 .70	1 .10	--	--	f	Open	38
707-R21B	13 .70	1 .10	--	--	f	Open	39
707-R22A	13 .70	1 .10	--	--	f	Open	40
707-R22B	13 .70	1 .10	--	--	f	Open	41
707-R23A	13 .70	1 .10	--	--	f	Open	42
707-R23B	13 .70	1 .10	--	--	f	Open	43
707-R24A	13 .70	1 .10	--	--	f	Open	44
707-R24B	13 .70	1 .10	--	--	f	Open	45
707-R25A	13 .70	1 .10	--	--	f	Open	76
707-R25B	13 .70	1 .10	--	--	f	Open	77
707-R26A	13 .70	1 .10	--	--	f	Open	78
707-R26B	13 .70	1 .10	--	--	f	Open	79
707-R27A	13 .70	1 .10	--	--	f	Open	80
707-R27B	13 .70	1 .10	--	--	f	Open	81

Stack Data for Point Sources
(Continued)

Building/ Location	Height[a] (m)	Diameter (m)	Width (m)	Length (m)	Exit Velocity (m/s)	Stack Type	Vent No.
707-R45A	13 .00	0 .84	--	--	f	Open	1
707-R45B	12 .86	0 .84	--	--	f	Open	2
707-R46A	12 .86	0 .81	--	--	f	Open	3
707-R46B	12 .86	0 .81	--	--	f	f	4
771-CMA	7 .67	0 .61	--	--	7 .60	Gooseneck	9
771-CRM8	7 .82	0 .45	--	--	11 .54	90°	1
771-CRM10	7 .25	--	0 .61	0 .51	2 .48	90°	8
771-MAI	50 .14	3 .12	--	--	8 .72	Open	f
774-202	7 .11	--	0 .41	0 .51	10 .98	Gooseneck	f
776-201/204/250[d]	12 .00	--	0 .74	6 .17	2 .41	Penthouse	f
776-202	16 .10	0 .52	--	--	5 .86	Rain Cap	f
776-205/206/207[e]	12 .00	--	0 .74	6 .17	4 .86	Penthouse	f
776-251	13 .00	--	0 .81	1 .52	8 .32	Wall penetration	45
776-252	13 .20	--	0 .91	0 .56	f	90° Wall penetration	44
778-LDY	8 .00	1 .22	--	--	5 .75	Open	50
779-729	26 .82	0 .96	--	--	7 .49	Open	f
779-782	6 .70	--	0 .91	1 .45	14 .67	Gooseneck	f
790	f	f	f	f	f	f	f
865-EEE	5 .66	--	1 .12	1 .52	7 .64	90°	63,64
865-WWW	5 .30	--	1 .42	1 .42	10 .65	90°	58,59
881-MA1	12 .40	2 .44	--	--	5 .66	Open	8
881-MA2	12 .40	2 .44	--	--	11 .13	Open	7
881-MA3	12 .40	2 .44	--	--	5 .28	Open	5
881-MA4	12 .40	2 .44	--	--	4 .62	Open	6
883-AAA	7 .41	--	1 .32	2 .50	7 .53	90°	44
883-BBB	7 .07	--	1 .32	2 .50	10 .50	90°	45
883-CCC	21 .34	1 .22	--	--	6 .40	Open	34
886-875	5 .95	--	1 .22	0 .61	9 .97	Gooseneck	15

Stack Data for Point Sources (Continued)

Building/ Location	Height[a] (m)	Diameter (m)	Width (m)	Length (m)	Exit Velocity (m/s)	Stack Type	Vent No.
889-MAI	9 .75	0 .76	--	--	6 .00	Open	15
991-985	6 .25	--	1 .22	0 .51	11 .90	Gooseneck	2
991-MAI	7 .21	--	1 .37	1 .52	1 .50	Gooseneck	41

[a] Above grade.

[b] 371-N01/N02 combined to one penthouse.

[c] 707-102 has two exhaust stacks combined.

[d] 776-201/204/250 combined to penthouse vent No. 24.

[e] 776-205/206/207 combined to penthouse vent No. 32.

[f] Data not available.

Notes:

--	=	Not applicable
m	=	Meters
m/s	=	Meters per second

APPENDIX E

METEOROLOGICAL DATA SET

Meteorological Data Set
Wind Speed and Stability Class, 1995

WIND DIRECTION[a]	STABILITY CLASS	Wind Speed Frequency (%)					
		0 to 3 (knots)	3 to 6 (knots)	6 to 10 (knots)	10 to 16 (knots)	16 to 21 (knots)	>21 (knots)
N	A	0.161	0.390	0.000	0.000	0.000	0.000
NNE	A	0.166	0.592	0.013	0.000	0.000	0.000
NE	A	0.349	0.630	0.000	0.000	0.000	0.000
ENE	A	0.221	0.592	0.000	0.000	0.000	0.000
E	A	0.268	0.793	0.013	0.000	0.000	0.000
ESE	A	0.339	0.668	0.000	0.000	0.000	0.000
SE	A	0.343	0.856	0.000	0.000	0.000	0.000
SSE	A	0.241	0.365	0.013	0.000	0.000	0.000
S	A	0.073	0.189	0.013	0.000	0.000	0.000
SSW	A	0.119	0.239	0.013	0.000	0.000	0.000
SW	A	0.212	0.202	0.000	0.000	0.000	0.000
WSW	A	0.098	0.164	0.000	0.000	0.000	0.000
W	A	0.108	0.126	0.013	0.000	0.000	0.000
WNW	A	0.213	0.214	0.013	0.000	0.000	0.000
NW	A	0.047	0.202	0.013	0.000	0.000	0.000
NNW	A	0.303	0.290	0.013	0.000	0.000	0.000
N	B	0.018	0.239	0.227	0.000	0.000	0.000
NNE	B	0.072	0.239	0.264	0.000	0.000	0.000
NE	B	0.076	0.302	0.491	0.000	0.000	0.000
ENE	B	0.044	0.227	0.302	0.000	0.000	0.000
E	B	0.046	0.252	0.302	0.000	0.000	0.000
ESE	B	0.038	0.327	0.428	0.000	0.000	0.000
SE	B	0.058	0.416	0.567	0.000	0.000	0.000
SSE	B	0.098	0.227	0.327	0.000	0.000	0.000
S	B	0.037	0.139	0.151	0.000	0.000	0.000
SSW	B	0.016	0.038	0.076	0.000	0.000	0.000
SW	B	0.047	0.088	0.063	0.000	0.000	0.000
WSW	B	0.045	0.063	0.139	0.000	0.000	0.000
W	B	0.004	0.050	0.088	0.000	0.000	0.000
WNW	B	0.043	0.038	0.101	0.000	0.000	0.000
NW	B	0.023	0.126	0.214	0.000	0.000	0.000
NNW	B	0.029	0.214	0.302	0.000	0.000	0.000
N	C	0.109	0.214	0.806	0.300	0.000	0.000
NNE	C	0.093	0.202	0.340	0.090	0.000	0.000
NE	C	0.029	0.126	0.264	0.050	0.000	0.000
ENE	C	0.037	0.076	0.189	0.000	0.000	0.000
E	C	0.009	0.076	0.214	0.050	0.000	0.000
ESE	C	0.062	0.176	0.466	0.090	0.000	0.000
SE	C	0.022	0.189	0.844	0.080	0.000	0.000
SSE	C	0.040	0.227	0.642	0.100	0.000	0.000
S	C	0.045	0.151	0.088	0.100	0.000	0.000
SSW	C	0.007	0.063	0.101	0.010	0.000	0.000

Meteorological Data Set
Wind Speed and Stability Class, 1995
(Continued)

WIND DIRECTION[a]	STABILITY CLASS	Wind Speed Frequency (%)					
		0 to 3 (knots)	3 to 6 (knots)	6 to 10 (knots)	10 to 16 (knots)	16 to 21 (knots)	>21 (knots)
SW	C	0.015	0.013	0.063	0.080	0.000	0.000
WSW	C	0.048	0.050	0.101	0.100	0.000	0.000
W	C	0.007	0.063	0.290	0.300	0.000	0.000
WNW	C	0.034	0.176	0.264	0.300	0.000	0.000
NW	C	0.037	0.076	0.176	0.200	0.000	0.000
NNW	C	0.022	0.189	0.479	0.100	0.000	0.000
N	D	0.170	0.302	1.209	0.700	0.100	0.000
NNE	D	0.449	0.542	0.856	0.700	0.090	0.000
NE	D	0.201	0.428	0.542	0.200	0.000	0.000
ENE	D	0.185	0.365	0.428	0.060	0.000	0.000
E	D	0.063	0.252	0.252	0.090	0.000	0.000
ESE	D	0.078	0.189	0.239	0.050	0.000	0.000
SE	D	0.160	0.264	0.479	0.200	0.050	0.000
SSE	D	0.100	0.277	0.718	0.500	0.080	0.000
S	D	0.116	0.403	0.957	0.600	0.200	0.000
SSW	D	0.308	0.793	1.171	0.500	0.200	0.000
SW	D	0.386	0.668	0.970	0.600	0.200	0.000
WSW	D	0.478	0.781	1.033	1.300	0.600	1.000
W	D	0.449	0.668	1.108	2.000	1.400	2.000
WNW	D	0.254	0.705	1.008	2.600	2.400	2.000
NW	D	0.132	0.466	1.272	1.400	0.400	0.000
NNW	D	0.286	0.642	1.234	1.100	0.200	0.000
N	E	0.101	0.302	0.151	0.000	0.000	0.000
NNE	E	0.101	0.202	0.113	0.000	0.000	0.000
NE	E	0.025	0.176	0.113	0.000	0.000	0.000
ENE	E	0.038	0.126	0.076	0.000	0.000	0.000
E	E	0.000	0.038	0.063	0.000	0.000	0.000
ESE	E	0.000	0.088	0.013	0.000	0.000	0.000
SE	E	0.050	0.101	0.088	0.010	0.000	0.000
SSE	E	0.038	0.139	0.176	0.000	0.000	0.000
S	E	0.050	0.327	0.592	0.200	0.000	0.000
SSW	E	0.038	0.428	0.491	0.200	0.000	0.000
SW	E	0.101	0.668	0.743	0.040	0.000	0.000
WSW	E	0.290	1.083	0.743	0.030	0.000	0.000
W	E	0.126	0.630	0.277	0.010	0.000	0.000
WNW	E	0.126	0.302	0.441	0.090	0.000	0.000
NW	E	0.063	0.252	0.567	0.040	0.000	0.000
NNW	E	0.038	0.264	0.302	0.090	0.000	0.000
N	F	0.241	0.441	0.025	0.000	0.000	0.000
NNE	F	0.152	0.239	0.013	0.000	0.000	0.000
NE	F	0.071	0.277	0.000	0.000	0.000	0.000

Meteorological Data Set
Wind Speed and Stability Class, 1995
(Continued)

WIND DIRECTION[a]	STABILITY CLASS	Wind Speed Frequency (%)					
		0 to 3 (knots)	3 to 6 (knots)	6 to 10 (knots)	10 to 16 (knots)	16 to 21 (knots)	>21 (knots)
ENE	F	0.161	0.202	0.000	0.000	0.000	0.000
E	F	0.074	0.202	0.025	0.000	0.000	0.000
ESE	F	0.289	0.378	0.000	0.000	0.000	0.000
SE	F	0.231	0.378	0.000	0.000	0.000	0.000
SSE	F	0.307	0.592	0.000	0.000	0.000	0.000
S	F	0.242	0.453	0.000	0.000	0.000	0.000
SSW	F	0.289	0.567	0.000	0.000	0.000	0.000
SW	F	0.411	0.416	0.013	0.000	0.000	0.000
WSW	F	0.508	0.579	0.000	0.000	0.000	0.000
W	F	0.597	0.592	0.013	0.000	0.000	0.000
WNW	F	0.478	0.768	0.050	0.000	0.000	0.000
NW	F	0.453	0.693	0.025	0.000	0.000	0.000
NNW	F	0.347	0.567	0.038	0.000	0.000	0.000

[a] Direction represents origin of winds relative to the Site.

DOE F 1332.15 (03-03) Combines previous version of DOE F 1332.15 and .16. All other editions are obsolete.

U. S. DEPARTMENT OF ENERGY
RECOMMENDATIONS FOR THE ANNOUNCEMENT AND DISTRIBUTION OF DEPARTMENT OF ENERGY (DOE) SCIENTIFIC AND TECHNICAL INFORMATION (STI)

(See instructions on reverse side. Use plain bond paper if additional space is needed for explanations.)

OMB Control No. 1910-1400 OMB Burden Disclosure Statement on reverse side

PART I *(DOE, DOE Contractors, Grantees, and Awardees complete)*

A. Product/Report Data

1. (Award) Contract No. DE-AC34-95RF00825

2. Title Rocky Flats 1994 Site Environmental Report

3. Product/Report Description

☐ a. Report *(Complete all that apply)*
(1) ☑ Print ☐ Nonprint *(specify)* _____
(2) ☐ Quarterly ☐ Semiannual ☑ Annual ☐ Final
☐ Topical ☐ Phase I ☐ Phase II
☐ Other *(specify)* _____
Dates covered January thru December 1994

☐ b. Conference/Meeting/Presentation *(Complete all that apply)*
(1) ☐ Print ☐ Nonprint *(specify)* _____
☐ Published proceedings
☐ Other *(specify)* _____
(2) Conference Title *(no abbreviations)* _____
Location *(city/state/country)* _____
Date(s) *(m/d/y)* / / thru *(m/d/y)* / /
Sponsor _____

☐ c. Software—Additional forms are required. Follow instructions on the back of this form.

☐ d. Other *(Provide complete description)* _____

B. Patent Information

Yes	No	
☐	☑	Is any new equipment, process, or material disclosed? If yes, identify page numbers _____
☐	☑	Has an invention disclosure been submitted? If yes, identify the disclosure number and to whom it was submitted. Disclosure number _____ Submitted to _____
☐	☑	Are there patent-related objections to the release of this STI product? If so, state the objections. _____

C. Contact *(Person knowledgeable of content)*

Name Joan Novy
Phone (303) 966-8336
Position Editor - annual SER
Organization RMRS Tech. Publications

PART II *(DOE/DOE Contractors complete/or as instructed by DOE contracting officer)*

A. DOE Identifiers

1. Product/Report Nos. DOE/RF/00825

2. Funding Office(s) *(NOTE: Essential data)* DOE/REEO

B. Copies for Transmittal to AD-21 (OSTI)

(STI must be of sufficient quality for microfilming/copying.)

☐ 1. One for classified processing
☐ 2. _____ *(number)* for standard classified distribution
☑ 3. Two unclassified for processing
☐ 4. _____ *(number)* for program unclassified distribution
☐ 5. UC/C Category _____
☐ 6. Additional instructions/explanations _____

(Do not identify Sigma categories for Nuclear Weapons Data reports, and do not provide additional instructions that are inconsistent with C below.)

C. Recommendation *("X" at least one)*

☑ 1. Program/Standard Announcement/Distribution *(Available to U.S. and foreign public)*
☐ 2. Classified *(Standard Announcement only)*
☐ 3. Special Handling *(Legal basis must be noted below.)*
☐ a. Unclassified Controlled Nuclear Information (UCNI)
☐ b. Export Control/ITAR/EAR
☐ c. Temporary hold pending patent review
☐ d. Translations of copyrighted material
☐ e. Small Business Innovation Research (SBIR)
☐ f. Commercializable information
☐ (1) Proprietary
☐ (2) Protected CRADA information
Release date / /
☐ (3) Other *(explain)* _____
☐ 4. Program Directed Special Handling *(copy attached)*

D. Releasing Official

A. Patent Clearance *("X" one)*
☐ Has been submitted for DOE patent clearance
☐ DOE patent clearance has been granted

B. Released by
(Name) J. A. Nesheim, Class'n Officer
(Signature) J. A. Nesheim
(Phone) (303) 966-4595
(Date) 10-27-95

INSTRUCTIONS

Purpose: This form provides the Office of Scientific and Technical Information (OSTI), AD-21, the data elements required to accurately process and/or announce and disseminate the result of work funded by the U.S. Department of Energy (DOE) or performed in DOE facilities.

When to use: Submit this form with each Scientific and Technical Information (STI) product/report title. When submitting electronically, include all relevant data elements, and prior to submission contact AD-21 at 615-576-1261.

1. DOE and DOE Contractors: Complete the entire form and submit with the STI product to AD-21 (OSTI) for processing in accordance with the requirements of DOE 1430.1C and 1430.2B. Reporting that may be required under the terms of the contract but is not appropriate for transmittal to AD-21 includes such things as contract proposals, funding status, routine construction or inventory reports, etc. *(Call 615-576-1261 for further clarification.)* Submit to:

U.S. Department of Energy
Office of Scientific and Technical Information (AD-21)
175 Oak Ridge Turnpike *(for shipments)*
P.O. Box 62 *(for mail)*
Oak Ridge, TN 37831

2. Financial Assistance Recipients: Normally, only Part I is to be completed. When completed, forward the form along with the STI product/report to the DOE Contracting Officer who will complete Part II and submit the package to AD-21. However, the DOE Contracting Officer may require the awardee to complete portions of Part II and also may require that the form and product/report be forwarded directly to AD-21. Check your specific requirements.

PART I

A. Product/Report Data

1. Contract (Award) No. Insert the DOE award or contract number(s) under which the work was funded.

2. Title. Provide the title exactly as on the product itself.

3.a., 3.b. and, 3.d. Self-explanatory.

3.c. Software. STI software must be submitted to the Energy Science and Technology Software Center (ESTSC). To obtain required forms and instructions, contact ESTSC at 615-576-2606.

B. Patent Information. Self-explanatory.

C. Contact. Self-explanatory.

PART II

A. DOE Identifiers

1. Product/Report Number. This is a unique identifier. A complete and accurate number is essential. AD-21 has approved identifiers for use by most DOE offices and Management and Operating (M&O) Contractors *(see examples below)*. For others, use DOE/ and the final seven characters from the applicable contract or grant number. A slash mark must separate the letters from the number. Complete the number with dashes followed by a sequential number for each product/report generated under the contract. For example, the first product/report number generated under contract number DE-AC03-79NE01834 should have the number DOE/NE/01834--1. The following are examples of format for multivolumes, parts, or revisions.

DOE/NE/01834--1-Vol. 1
DOE/NE/01834--1-Pt. 1
DOE/NE/01834--1-Rev. 1

Product/Report numbers are to be structured exactly as specified in these instructions. Any modification must be approved by AD-21. The following are examples of approved identifiers.

Product Producer	Approved Sequential Identifier
Headquarters DOE	DOE/NE--193
DOE Field Offices	DOE/OR--759
Major Project Offices	DOE/LLW--198
M&O Contractors	ANL/TM--482

For work performed for other agencies, the funding agency may assign their product/report number. If so, provide their number.

2. Funding Office. This information is essential. Insert the name, symbol, or B&R code of the DOE office providing support/funding. For projects funded by more than one office, indicate all sources of DOE funding. For work for others, indicate funding agency.

B. Copies for Transmittal to AD-21 (OSTI)

All STI products must be in a form that can serve as the record copy and be of sufficient quality for successful reproduction (optical scanning, microfiche, and other media). For nonprint media, refer questions to AD-21 at 615-576-1268.

1. and 3. For printed products, one copy must be original ribbon or offset and be completely legible according to DOE 1430.2B. A high-contrast photocopy is acceptable as a second reproducible copy.

2. and 4. When submitting print copies for distribution by AD-21, forward the number of copies specified in DOE/OSTI--3679-Rev. 75 or DOE/OSTI--4500.

5. UC/C Category This code identifies the appropriate distribution of the product/report. Provide the appropriate unclassified code from DOE/OSTI--4500 or classified code from DOE/OSTI--3679-Rev.75. For copies of these documents contact AD-21 at 615-576-8401.

6. Provide sufficient instructions for AD-21 to accurately process, announce, or distribute the STI product. Include complete funding information when requesting services. Use this block to note when mailing labels are included.

C. Recommendation

DOE is obligated to make available the results from federally funded work to the widest extent possible. AD-21 makes distribution of STI products on behalf of DOE strictly in accordance with existing laws, regulations, and/or written DOE Program Office guidance. Recommendations to restrict access to STI products must have a legal basis or be accompanied by written programmatic guidance. Questions concerning current laws and guidance may be referred to AD-21 at 615-576-1268.

1. Program/Standard Announcement/Distribution. The unrestricted, unlimited distribution of the product includes abstracting in *Energy Research Abstracts (ERA)*, DOE distribution to appropriate addressees listed in DOE/OSTI--4500, to those Government Printing Office (GPO) Depository Libraries maintaining energy collections, and to the National Technical Information Service (NTIS) for sale to the U.S. and foreign public.

2. Classified. STI products will be announced by AD-21 in accordance with DOE/OSTI--3679-Rev. 75.

3. Special Handling. The specific legal basis for restricting access must be checked. All STI products will be announced/distributed strictly in accordance with existing laws, regulations, or official guidance.

CRADAs—STI products generated under Cooperative Research and Development Agreements (CRADAs) under the National Competitiveness and Technology Transfer Act of 1989. Please include the estimated release date for the STI product in accordance with the terms of the agreement.

4. Program Directed. A copy of the specific guidance (or if the guidance is lengthy, a reference will be acceptable) must be attached.

D. Releasing Official

The appropriate official differs based on the source of STI, the contracting instrument, and the internal organizational responsibilities. Do not forward this form to AD-21 until after appropriate review and release.

OMB BURDEN DISCLOSURE STATEMENT

Public reporting burden for this collection of information is estimated to average 5 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Information Resources Management, AD-244-GTN, Paperwork Reduction Project (1910-1400), U.S. Department of Energy, Washington, DC 20585; and to the Office of Management and Budget (OMB), Paperwork Reduction Project (1910-1400), Washington, DC 20503.

DOE F 1332.15
(10-90)
All other editions are obsolete

U.S. DEPARTMENT OF ENERGY
DOE AND MAJOR CONTRACTOR RECOMMENDATIONS FOR ANNOUNCEMENT AND DISTRIBUTION OF DOCUMENTS

(See Instructions on Reverse Side)

OMB Control
1910-1400
Burden Disclosure Statement on Back

1. DOE Report No.	2. DOE Contract No.	3. DOE Funding Office	4. OSTI UC or C Category
RFP-	DE-AC04-90DE62349	RFO	

5. Title

6. Type of Document ("x" one)
a. Scientific and technical report: ☐ monthly ☐ quarterly ☐ annual ☐ final ☐ topical ☐ special/public interest ☐ other
b. Conference paper: Name of conference (no abbreviations)_____
Location (city/st/ctry)_____
Date (mo/day/yr)_____ Sponsor_____
Contents: ☐ proceedings ☐ viewgraphs ☐ paper ☐ poster sessions
c. Computer Media:
Document is accompanied by ☐ magnetic tape(s)_____
☐ diskette(s)_____
☐ other (specify)_____
d. Other (e.g., journal article, manuscript, manual, etc.) (specify)_____

7. Copies Transmitted to OSTI ("x" one or more).
☐ a. Copies for unclassified distribution.
☐ b. Twelve copies for OSTI processing and NTIS sales.
☐ c. Twenty-five additional copies for special/public interest.
☐ d. One reproducible copy for OSTI processing.
☐ e. Copies for special distribution.
☐ f. Copies for classified distribution as defined in M-3679
☐ g. One copy for OSTI classified processing.

8. Document contains information pertaining to any of the following:
☐ Yes ("x" one or more) ☐ No (If no, unlimited distribution may be made within the U.S. In addition, copies may be made available to foreign requestors through exchange agreements or NTIS sales.
☐ a. Classified
(Announce to appropriate recipients as listed in M-3679, "Standard Distribution for Classified and Technical Reports")
☐ b. Export Control/ITAR/EAR
☐ c. Proprietary Data
☐ d. Small Business Inovative Research (SBIR)
☐ e. Unclassified Controlled Nuclear Information (UCNI)
☐ f. Patent Hold
☐ g. Translations of copyrighted material
(Boxes b-g will be announced to Government agencies and their contractors)
☐ h. Cooperative Research and Development Agreement (CRADA)
☐ i. Other (Explain)_____
(This designation must be in accordance with written DOE Program Office guidance. Attach copy of guidance.)

Upon demand, OSTI will make distribution of these documents in accordance with existing laws, regulations, and/or written program office guidance.

9. Patent Information
a. Does this information product disclose any new equipment, process, or material? ☐No ☐Yes If so, identify page nos.____
b. Has an invention disclosure been submitted to DOE covering any aspect of this information product? ☐ No ☐ Yes
If so, identify the DOE (or other) disclosure number and to whom the document was submitted.
c. Are there any patent-related objections to the release of this information product? ☐No ☐Yes If so, state the objections.

10. Additional information, remarks, and special handling instructions. (*Do not* identify Sigma categories for Nuclear Weapon Data reports, and *do not* provide additional instructions which are inconsistent with item 8 above.) (Continue on separate sheet, if necessary.)

11. Submitted by (Name and Position) (Please print or type)		Phone
Organization	Signature	Date